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UNION OF SOUTH AFRICA

DEPARTMENT OF COMMERCE AND INDUSTRIES

DIVISION OF FISHERIES

INVESTIGATIONAL REPORT No. 23

THE SOUTH AFRICAN PILCHARD

(Sardinops ocellata)

AND MAASBANKER

(Trachurus trachurus)

BIRD PREDATORS, 1954-55

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BY

D. H. DAVIES, M.Sc., Ph.D.

(Senior Professional Officer)

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Contents

PAGE.

1. Summary 3
2. Introduction 4
3. The Cape Gannet 4
   - (i) General 4
   - (ii) The Food of the Gannet 5
   - (iii) Comparison of feeding for first and second years 6
   - (iv) Digestion and food capacity 7
   - (v) Discussion 8
4. The Cape Cormorant 9
   - (i) The food of the cormorant 9
   - (ii) Comparison of feeding for first and second years 10
   - (iii) Digestion and food capacity 11
   - (iv) Cormorant counts in St. Helena Bay 12
   - (v) Discussion 14
5. The Cape Penguin 15
   - (i) The food of the penguin 15
   - (ii) Comparison of feeding for first and second years 16
   - (iii) Digestion and food capacity 16
   - (iv) Discussion 17
6. Birds as indicators of shoal fish 18
7. General discussion 19
8. Recommendations 20
9. Acknowledgments 21
10. References 21

I. Summary.

A second year of investigation into the feeding habits of the three important fish-eating birds of the main pelagic, commercial fishing area of St. Helena Bay off the West coast of the Union of South Africa has to a large extent confirmed the findings of the previous year (Davies, 1955).

The birds investigated were the Cape Gannet (*Morus capensis*), the Cape Cormorant (*Phalacracorax capensis*) and the Cape Penguin (*Spheniscus demersus*).

1. Based on the monthly examination of the stomach contents of 289 birds shot over a period of two years, the food of the gannet in the St. Helena Bay area was found to consist entirely of fish of the following species:—

(*a*) Pilchard (*Sardinops ocellata*).

(*b*) Maasbanker (*Trachurus trachurus*).

(*c*) Anchovy (*Engraulis japonicus*).

(*d*) Harder or Mullet (*Liza ramada*).

(*e*) Mackerel (*Scomber japonicus*).

2. Over 50 per cent of the fish eaten by the gannet are pilchards and of these more than 75 per cent fall within the size range of the normal commercial catches of pilchards, the remainder being juveniles.

3. Only 16 per cent of the fish eaten by the gannet are maasbankers and of these 75 per cent fall within the size range of the normal commercial catches of maasbankers, the remainder being juveniles.

4. From observation and experiment, the average capacity of the gannet's stomach and oesophagus is calculated to be 1,000 cc which is equivalent to 2 lb. 3 oz.

5. From observation and experiment, it was concluded that the average adult gannet consumes approximately 4 lb. of fish per ideal fishing day.

6. A new estimate of the gannet population feeding in St. Helena Bay based on aerial photography, gives the number of birds as 112,000.

7. Gannets in the St. Helena Bay area eat 54,500 tons of fish per year of which 29,500 tons consist of pilchards and 8,700 tons of maasbankers.

8. Based on the examination of the stomach contents of 114 birds shot over a period of two years, the food of the Cape cormorant in the St. Helena Bay area was found to consist of the following:—

(*a*) Pilchard (*Sardinops ocellata*).

(*b*) Anchovy (*Engraulis japonicus*).

(*c*) Klipfish (*Clinus* spp.).

(*d*) Maasbanker (*Trachurus trachurus*).

(*e*) Hottentot (*Pachymetopon blochii*).

(*f*) Shrimp (*Palaemon pacificus*).

(*g*) Rock Lobster (*Jasus lalandii*).

9. Over 50 per cent of the organisms eaten by the cormorant are pilchards and of these nearly 70 per cent fall within the size range of the normal commercial catches of pilchards, the remainder being juveniles.

10. Maasbankers of commercially-exploitable size are considered to be of minor importance in the feeding of the cormorant in the area.

11. From observation and experiment, the average capacity of the cormorant's stomach and oesophagus is calculated to be 276 cc which is equivalent to 10 oz.

12. From observation and experiment, it was concluded that the average cormorant consumes approximately 1 lb. 4 oz. of food per ideal fishing day.

13. A new estimate of the cormorant population feeding in St. Helena Bay based on a system of regular counting carried out in the area over a period of two years gives a maximum figure of 42,000 cormorants and an average figure of 20,000 cormorants.

14. The average number of cormorants (20,000) eat 3,000 tons of fish per year, of which 1,500 tons consist of pilchards and 250 tons of maasbankers.

15. Based on the examination of the stomach contents of 129 birds shot over a period of fifteen months, the food of the Cape Penguin in the St. Helena Bay area was found to consist of the following:—

(*a*) Pilchard (*Sardinops ocellata*).

(*b*) Anchovy (*Engraulis japonicus*).

(*c*) Maasbanker (*Trachurus trachurus*).

(*d*) Mackerel (*Scomber japonicus*).

(*e*) Squid (*Loligo reynaudi*).

(*f*) Crab larvae.

16. Of the organisms eaten by the penguin, 48 per cent are pilchards but only 43 per cent of these fall within the size range of the normal commercial catches of pilchards, the majority eaten being juveniles.

17. Maasbankers of commercially-exploitable size are considered to be of no importance in the feeding of the penguin in the area.

18. From observation and experiment, the average capacity of the penguin's stomach and oesophagus is calculated to be 800 cc which is equivalent to 1 lb. 12 oz.

19. From observation and experiment, it was concluded that the average penguin consumes approximately 3 lb. 8 oz. of food per ideal fishing day.

20. An estimate of the penguin population feeding in St. Helena Bay gives an average figure of 5,000 birds.

21. These birds eat 2,000 tons of fish per year of which 1,000 tons consist of pilchards and 60 tons of maasbankers.

22. Gannets, cormorants and penguins are estimated to consume about 60,000 tons of fish per year in the St. Helena Bay area. Of this, 32,000 tons consist of pilchards and 9,000 tons of maasbankers.

2. Introduction.

This paper is the sixth in a series dealing with the South African Pilchard *Sardinops ocellata*, and is the second report on the bird predators of this species. The first report (Davies, 1955) on the predation of the pilchard by sea-birds in the main commercial fishing area of St. Helena Bay, covered the year March 1953 to February, 1954. The present report covers the year March, 1954 to February, 1955.

Full details regarding the problem, the area in which the research was carried out, the methods used, the procedure adopted and the assessment and presentation of the results are given in the first report. These topics are omitted in this report, but improvements of methods based on criticisms of the first report are discussed. It may be said, however, that the findings of this report confirm and extend those of the previous report.

It is stressed that these investigations were confined to the main commercial fishing area for pilchards and maasbankers in Union waters, viz. St. Helena Bay, where the largest concentrations of predatory sea-birds are found.

3. The Cape Gannet.

(i) General.

The Cape gannet is known locally as the malgas (or *malagas*) and *malgas* is the official Afrikaans name for this bird. It was generally thought that the word *malgas* was a corruption of *mal gans* = mad goose, but according to Kloeke (1954) *malgas* is a corruption of the original Portuguese name for the gannet which was *mangas de velludo* = velvet sleeves. The *de velludo* was dropped and *mangas* became *malagas* and later *malgas*.

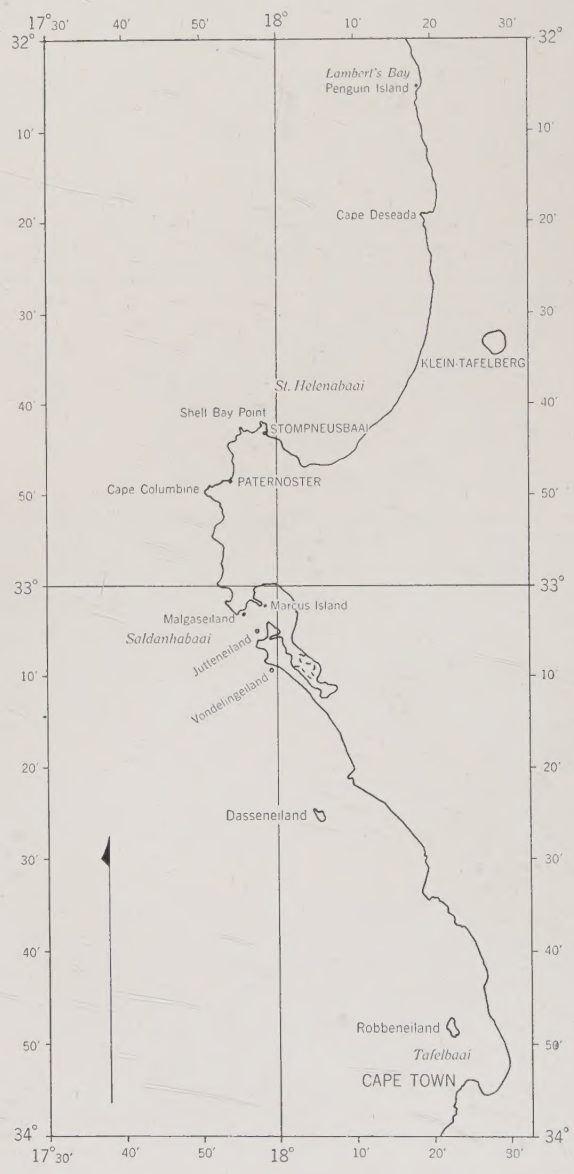

FIG.1 THE WEST COAST

Recent ring returns have shown the Cape gannet to be even more widely distributed than was previously thought. According to Ashton (1954), birds ringed on Malgas Island have been recovered

from the Cameroons on the West coast some 2,600 miles N.N.W. of Malgas Island, and from Zanzibar on the East coast.

In spite of this extremely wide range, however, it is most unlikely that large scale migrations throughout the entire range take place. The migrations appear to be confined to the young birds. The bulk of the adult gannet population maintains close contact with shoals of pelagic fish such as pilchards, anchovies and small maasbankers, though the gannets tend to lose contact during the breeding season or in adverse weather.

The largest concentrations of pelagic fish in Union waters are found in the area between Lambert's Bay and Dassen Island, and this coupled with the presence of nearby islands which provide convenient rookeries, permits the permanent congregation of large numbers of gannets. Aerial census figures will probably reveal that the largest numbers of gannets are permanently concentrated in this area of the Union's coastline.

It is therefore important to be able to assess the depredations of the gannet on the commercially-important fish which are found in the St. Helena—Saldanha Bay area.

(ii) The Food of the Gannet.

(See *Tables* 1–3 *and Plates* 1, 2.)

Gannets were shot during every month of the year and the examination of the stomach contents of 191 birds showed that their food consisted of the following:—

(*a*) Pilchard, *Sardinops ocellata* (Pappe).

(*b*) Maasbanker, *Trachurus trachurus* Linn.

(*c*) Anchovy, *Engraulis japonicus* (Houttuyn).

(*d*) Harder or Mullet, *Liza ramada* (Risso).

(*e*) Mackerel, *Scomber japonicus* Houttuyn.

(*f*) Fish remains, unrecognisable.

(a) Pilchard.

Pilchards were found to make up 50 per cent of the food of the gannet by frequency and 58 per cent by weight (see Tables 2, 3 and Plate 2, Figs. 1 and 2).

Although pilchards were not often found mixed with other species of fish in gannet stomachs, they were occasionally mixed with maasbankers or anchovies. The numbers of pilchards per stomach varied from 1 to 35 and depended to a large extent on the size of fish. The mean length* of pilchards eaten during the year was 22·2 cm and the range was 10·0–27·8 cm. Pilchards eaten by gannets fall into two broad size categories, i.e. those under 12 cm and those over 20 cm. Twenty-two per cent† of gannets had eaten pilchards under 12 cm and seventy-eight per cent† over 20 cm. Small pilchards only were eaten during the months of November, January and February while pilchards over 20 cm were eaten during every month of the year except November and February.

The greatest weight of pilchards found in a single gannet stomach was 699 gm.

As already stated, pilchards were eaten during all seasons of the year (see Plate 1, Figs. 1 and 2)—juvenile fish in late spring and summer when others were not available and larger fish during autumn, winter and spring.

The commercial catches of pilchards made in St. Helena Bay and off Saldanha Bay consist of length groups 20–28 cm. Therefore, *the pilchards eaten by the gannets in this area consist mainly of commercially-exploitable fish.*

Note on the gannet in Natal:—

As stated in the first report, the pilchard shoals migrating northward along the Natal coast in June, 1954, were accompanied by large numbers of gannets. In 1955, however, only three gannets were seen during 10 days of continuous observation. Two of these were adult and one a juvenile. Although the pilchard shoals were quite as large as those seen in 1954, no other birds were seen preying on them.

The most likely explanation for this is that at some stage during their migration the fish managed to evade the gannets either by going deeper or by moving farther out to sea.

It is hoped that it will be possible to follow fishing gannets from Cape Point past Cape Agulhas up the East coast, taking regular samples of birds for stomach-content examination in order to throw more light on the migration of pilchards and anchovies.

(b) Maasbanker.

Maasbankers were found to make up 9 per cent of the total food of the gannet by frequency and 23 per cent by weight (see Tables 2, 3 and Plate 2 Figs. 1 and 2).

* The lengths of all food organisms are total lengths.

† These percentages refer only to those gannets which had eaten pilchards.

Maasbankers found in gannet stomachs were seldom mixed with other species. The numbers of maasbankers per stomach varied from 1 to 4 and consisted of fish 9·5–29·5 cm in length. The mean length of maasbankers eaten during the year was 23·1 cm. It was found that 25 per cent* of gannets had eaten maasbankers under 12 cm and 75 per cent* over 20 cm.

Maasbankers were eaten during all seasons (see Plate 1). Small maasbankers (under 12 cm in length) were recorded in gannet stomachs during February only, while the larger fish (over 20 cm in length) were found during April, August and September.

Although maasbankers were known to be present in the area during other months of the year, gannets showed no preference for this species while pilchards or anchovies were present. Although the majority of maasbankers eaten by gannets were of a size caught in the commercial catches, the bulk of the commercial catches consisted of larger fish.

(c) Anchovy.

Anchovies were found to make up 21 per cent of the total food of the gannet by frequency and 9 per cent by weight (see Plate 2, Figs. 1 and 2).

Anchovies in gannet stomachs were sometimes mixed with pilchards. The numbers of anchovies per bird varied from 1 to 20 and consisted entirely of young fish approximately 12 cm in length.

Anchovies were eaten by gannets during winter, spring and summer and were recorded in stomach contents in the months August through to February (see Plate 1).

Although the gannet feeds extensively on anchovies, viz. 21 per cent of its diet by frequency, a large number of individuals are required for a meal due to their small size. This is reflected in the weight analysis which was only 9 per cent of the gannet's food. The time taken for a gannet to catch sufficient anchovies for a meal would probably be far greater than that required to catch a meal of pilchards.

(d) Harder.

Harders were found to make up less than 1 per cent of the total food of the gannet by frequency and 6 per cent by weight. Harders were recorded on a single occasion during September.

It is felt that due to their presence in the St. Helena—Saldanha Bay areas during most months of the year they form a reserve food supply of some importance.

(e) Mackerel.

Mackerel were found to make up less than 1 per cent of the total food of the gannet by frequency and the same percentage by weight. Thus their presence in a single gannet stomach is worthy of mention only because it reflects the presence of mackerel in the St. Helena Bay area during the month of January, 1955.

(f) Fish remains.

Fish remains were found in stomachs on many occasions, and the species concerned were not identified due to advanced digestion.

Note on feeding of the gannet away from St. Helena Bay:—

From time to time gannets were shot between Cape Columbine and Table Bay in order to find out the species of shoal fish present in the area.

During the year gannets were found to have eaten the following species in this area:—

pilchard, maasbanker, anchovy, mackerel, skipper *Scomberesox saurus* (Walb.) and squid (*Loligo reynaudi*).

(iii) Comparison of Feeding for the First and Second Years.

The second year of monthly sampling of stomachs has fully confirmed the previous findings on the food of the gannet in the St. Helena Bay area. The lists of food organisms for the gannet, viz. pilchard, maasbanker, anchovy, mackerel, harder and fish remains, for the two years were identical.

Pilchards were eaten to the same extent in both years and were shown to be by far the most important organism eaten by the gannet in the area.

Maasbankers were eaten to a lesser degree by frequency but to a greater degree by weight during the second year, thus on an average maintaining their position of second in importance.

Anchovies were eaten to a lesser degree as indicated by both frequency and weight, but retained their position of third in importance.

* These percentages refer only to those gannets which had eaten maasbankers.

Harders were eaten to the same extent in both years and mackerel to a lesser degree than in the previous year.

Rather less fish remains were positively identified during the second year.

Considering the basis on which the feeding data were collected the results for two separate years could hardly have been in closer agreement. It may therefore be said that *in the area of the main pelagic fisheries of the Union, viz. the St. Helena Bay area, gannets feed mainly on pilchards, to a fair degree on maasbankers and anchovies and to a minor degree on harders and mackerel. The majority of pilchards and maasbankers eaten consist of fish which are commercially exploited but juveniles of both species are also eaten.*

(iv) Digestion and Food Capacity.

Six live adult gannets were obtained from Malgas Island and placed in an enclosure provided with running sea water and away from any form of disturbance. They were given live harders to eat and allowed 24 hours in which to settle down. Each bird was then placed in a large basket which was placed in subdued light away from any disturbance and given no food for twelve hours.

The following procedure was then adopted:—

Live harders were caught from an aquarium tank, stunned, measured, weighed and their individual volumes taken by displacement of water in a measuring cylinder. A certain number, in most cases three, were then force-fed to each of the gannets in their baskets. After each fish had been introduced, a small amount of sea water was squirted down the gannet's gullet by means of a plastic wash-bottle in order to provide lubrication and because feeding gannets were frequently observed swallowing water after having swallowed a fish. Every effort was made to disturb the gannet as little as possible while force-feeding was in progress. It was found that the bird remained fairly quiet if a cloth was held over its eyes. While some birds swallowed the harders as soon as they had been introduced into the gullet, others regurgitated the fish violently, but if a rubber band was slipped over the beak after feeding the bird was unable to regurgitate but could still open its beak sufficiently for heavy breathing, i.e. breathing which could not be carried out through the nares. This method was entirely sucessful with four of the five birds fed; one refused to swallow any fish whatsoever.

After a period of one hour the first bird was killed and the stomach contents examined, weighed and their volume measured. The same procedure was adopted for the second bird after two hours, the third bird after three hours and the fifth bird after two hours. The time-lapse was limited to three hours as only a few fish were available and it was thought that complete digestion might have taken place if they were allowed to remain longer.

It will be seen from Table 4 that after one, two or three hours in the stomach, approximately the same amount of digestion had taken place. The soft parts of the harders, i.e. mainly the flesh and viscera had become mush and only the hard parts remained in recognisable form. The area of greatest digestive activity was at the posterior end of the stomach.

It seems evident therefore, that softening and preliminary digestion of fish flesh and soft parts and partial evacuation of the stomach by the gannet is immediate and rapid but that it may take a considerable time for the mush and hard parts to move on from the stomach into the intestine. It is possible that the process becomes accelerated when a full meal is eaten, filling the stomach and causing maximum peristalsis. It was not possible to test this by force-feeding a gannet due to regurgitative reaction after a certain amount of food had been fed.

The sixth gannet was killed and its stomach and oesophagus immediately removed. While still warm the top of the oesophagus was connected by means of a tube to a water tap and the severed connection to the intestine held closed. The tap was turned on and water allowed to run in slowly until the stomach and oesophagus were fully distended. The bird used for this purpose weighed 4 lb. and, although adult, was a small individual. The water from the stomach was then poured into a measuring cylinder and the volume read. This procedure was carried out three times and the fourth time continued until the stomach wall ruptured. The mean of the three readings was found to be 900 cc, and the maximum (i.e. fourth reading) 1,150 cc. The stomach and oesophagus were removed for greater convenience, but in case this might allow abnormal expansion to take place, they were replaced in a fully-distended condition. The body cavity was, however, still not completely filled.

The maximum weight of fish recorded in a large gannet's stomach and oesophagus was 1,200 gm [2¾ lb. (see first report)]. This is equivalent to a cubic capacity of about 1,200 cc. It is likely therefore that *the average capacity of the gannet's stomach and oesophagus is in the neighbourhood of* 1,000 *cc.*

While it is fully realised that the rate of digestion of birds held in captivity may be quite different from that of birds in their natural surroundings, it is felt that under the conditions described, where every precaution was taken to ensure that the birds were disturbed as little as possible, the results obtained are not very different from normal.

(v) Discussion.

The gannet population of the West coast of the Union which is concentrated in the St. Helena—Saldanha Bay area feeds almost entirely on fish. The species eaten in greatest quantity is the pilchard which is one of the most important commercial species in the Union. Maasbankers are eaten to a lesser degree than the pilchard but nevertheless in fair numbers and are also very important commercially. The other species eaten are the anchovy, of potential commercial importance, the mackerel and the harder, both of which are of minor commercial importance.

Over 75 per cent of the pilchards and maasbankers eaten by the gannet fall within the size limits of the fish caught by commercial boats. Active feeding takes place during the entire year in the area of commercial fishing as shown by the records of pilchards in stomach contents during all months of the year. Maasbankers, on the other hand, were recorded during six months only.

In the previous estimate of the consumption of fish by gannets, (see first report), it was considered that a full meal, or the total capacity of the gannet was 1,200 gm or nearly 3 lb. of fish, but for the sake of caution half this amount, viz. 1½ lb. was taken as an average gannet meal. It is now considered that the average capacity of the gannet is close to 1,000 gm or 2·2 lb. (see previous section). From careful observation it has been established that when fish are available and in normal circumstances (excluding the breeding season) the gannet continues feeding until it is replete.

As shown in the first report, if an allowance of an average of 10 hours of daylight a day for fishing all the year round (a very conservative allowance) is made, 1½ hours for searching for prey, 1 hour for fishing and 2½ hours (i.e. 3½ hours after the commencement of fishing operations) for sufficient digestion to have taken place to leave enough space for the start of the next meal, i.e. a total of five hours for one operation, then two complete feeding operations can be carried out in one day. This may be termed an " ideal fishing day ".

During one feeding day, therefore, a gannet will consume approximately 4 lb. of fish. From daily meteorological reports made at Cape Columbine over a period of ten years (see Table 14 and Plate 9) wind data were used in order to find out the average number of days per year which could be reckoned as non-feeding days for birds due to unsuitable weather conditions.

After a great deal of observation it was considered that *effective* feeding of gannets, cormorants and penguins ceased at a wind velocity of about 15 m.p.h. i.e. Beaufort force 4 with accompanying sea conditions. Of the three species, single gannets have been seen diving in up to force 6 winds, but with doubtful success, as birds shot under these conditions were found to be empty. Mass feeding of gannets does not normally take place beyond winds of force 4.

From the wind frequencies (see Table 14) provided by the Weather Bureau, it was calculated that 18 per cent of winds per year are force 4 and over, while only 7 per cent are force 5 and over. As the maximum wind velocity for effective feeding (15 m.p.h.) falls within the limits of force 4, the period in each year during which weather conditions make feeding impossible lies between 7 and 18 per cent i.e. between 1½ and 2 months per year.

One third of the year has therefore been discounted for purposes of the feeding assessment of gannets and is calculated to include bad weather (2 months), breeding activity of the birds (1 month) and the periodic non-availability of fish (1 month). It is considered most unlikely that so large a portion of the year would be entirely unprofitable for the birds. *On this basis each bird will have eaten* 4 *lb. of fish every day for* 244 *days each year, i.e.* 976 *lb. per bird per year.*

Previous estimates of the gannet population of the St. Helena Bay—Saldanha Bay area are doubted by Rand (1955), whose estimate of the gannet population of Malgas Island is 40,600 birds based on a ground survey and aerial photographs. A previous estimate by Broekhuysen (1951) was 131,000 birds, showing a discrepancy between the two counts of 90,400 birds. According to Rand the gannet population of Penguin Islet at Lambert's Bay is approximately 25,000 birds making the total number for the two islands 65,600. The estimated total number of gannets used in the previous assessment of feeding was 200,000.

While it is generally believed that a decrease in the numbers of gannets on Malgas Island has occurred since 1951, and a known decrease occurred in 1954, it is neither apparent nor likely that the numbers have decreased to the extent of 90,400 birds. The main reason for the discrepancy lies in the methods of counting and estimating the colonies. *Until more accurate figures are available from the aerial survey of the islands* to be carried out in the near future, it seems most reasonable to take the total estimate for Malgas Island as the mean between the estimates of Broekhuysen (131,000 birds) and Rand (40,600 birds) which is 85,800 gannets. The total for Penguin Islet, Lambert's Bay, may be taken as 25,000 gannets and a general estimate for the remaining birds in the St. Helena Bay—Saldanha Bay area 1,200 birds. Thus the total estimated number of gannets in the area becomes 112,000.

With an estimated total population of gannets of 112,000 *feeding at the rate of* 976 *lb. of fish per bird per year, a total of* 54,656 *tons—in round figures* 54,500 *tons of fish will be eaten by the gannet population of the St. Helena Bay—Saldanha Bay area per year.*

If the gannets eat 54,500 *tons of fish per year, approximately* 29,500 *tons consist of pilchards and* 8,700 *tons of maasbankers, representing approximately* 34 *per cent and* 7 *per cent respectively of the total commercial catches for the year* 1954.

4. The Cape Cormorant.

(i) The Food of the Cormorant.

Cormorants were shot during every month of the year in the St. Helena Bay area, and the examination of the stomach contents of 77 birds showed that their food consisted of the following:—

(*a*) Pilchard, *Sardinops ocellata* (Pappe).

(*b*) Anchovy, *Engraulis japonicus* (Houttuyn).

(*c*) Klipfish, *Clinus* spp.

(*d*) Maasbanker, *Trachurus trachurus* Linn.

(*e*) Hottentot, *Pachymetopon blochii* Val.

(*f*) Fish remains, unrecognisable.

(*g*) Shrimp, *Palaemon pacificus* (Stimpson).

(*h*) Rock Lobster, *Jasus lalandii* Milne Edwards.

(a) Pilchard.

Pilchards were found to make up 35 per cent of the total food of the cormorant by frequency and 67 per cent by weight (see Tables 6 and 7 and Plate 4 Figs, 1 and 2).

Pilchards found in cormorant stomachs were not generally mixed with other food organisms. The number of pilchards per stomach varied from 1 to 29 depending largely on the size of fish caught. The mean total length of pilchards eaten during the year was 16·6 cm and the length range 5·5–25·8 cm. The pilchards eaten fell into two main size categories, i.e. those under 12 cm and those over 20 cm. Thirty-two per cent* of cormorants had eaten pilchards under 12 cm and sixty-eight per cent* over 20 cm. The small pilchards were eaten only during the months of September, January and February, while pilchards over 20 cm in length were eaten during May, September and October. Pilchards of all sizes were eaten during seven months of the year (see Plate 3 Figs. 1 and 2). It is interesting to note that small pilchards under 12 cm in length were also eaten by gannets during the months of January and February.

The greatest weight of pilchards found in a single cormorant stomach was 168·8 gm.

Therefore, *the pilchard is the most important food organism of the cormorant in the St. Helena Bay area and the majority of pilchards eaten are commercially-exploitable fish.*

(b) Anchovy.

Anchovies were found to make up 15 per cent of the total food of the cormorant by frequency and 17 per cent by weight (see Plate 4, Figs. 1 and 2).

Anchovies were not often found mixed with other species in the stomachs but were occasionally mixed with pilchards. The anchovies were small- and medium-sized fish of mean length 9·3 cm.

* These percentages refer only to those cormorants which had eaten pilchards.

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Anchovies were recorded in winter, spring and summer from August to October and in February (see Plate 3, Figs. 1 and 2), and were of some importance in the general diet of the cormorant.

(c) **Klipfish.**

Klipfish were found to make up 14 per cent of the total food of the cormorant by frequency and 5 per cent by weight (see Plate 4, Figs. 1 and 2).

Klipfish were not mixed with other species in the stomachs and averaged 7 cm in length.

They were recorded in stomach contents during spring, summer and autumn in the months of March, July, September, November and January (see Plate 3, Figs. 1 and 2).

Klipfish were found in the stomachs of cormorants obtained close inshore and it is likely that they form an important food of birds in the vicinity of rookeries and also when pelagic shoal fish are scarce.

(d) **Maasbanker.**

Maasbankers make up 11 per cent of the total food of the cormorant by frequency and 5 per cent by weight (see Plate 4, Figs. 1 and 2).

They were found mixed with pilchards in stomachs. The number of maasbankers per stomach varied from 1 to 2 and consisted of fish of length range 6·0–23·7 cm, with a mean of 12·2 cm. It was found that 75 per cent* of cormorants had eaten maasbankers under 12 cm in length and 25 per cent* over 20 cm.

Maasbankers were eaten during spring and summer (see Plate 3, Figs. 1 and 2) during the months September, October, November and February. Small maasbankers under 12 cm were eaten in September, November and February and large fish over 20 cm in September only.

Large, commercially-exploitable maasbankers may be regarded as being of minor importance as food organisms of the cormorant, while juveniles are important in certain seasons.

(e) **Hottentot.**

A single juvenile hottentot of length 6·8 cm was recorded in a cormorant stomach during November. The bird was shot close inshore and the record is of interest as it may indicate that juveniles of this abundant coastal species may at times form a reserve food supply.

(f) **Fish remains.**

Remains of fish were frequently found in cormorant stomachs but, due to advanced digestion, identification was not possible.

g) **Shrimp.**

The common shrimp frequently seen in rock pools in this area was found to make up 4 per cent of the diet of the cormorant by frequency but less than 1 per cent by weight.

Shrimps were found in the stomachs of cormorants shot close inshore and were not mixed with other organisms.

They were recorded during autumn and spring in March, October and November, (see Plate 3, Figs. 1 and 2) and may be of some importance as a reserve food supply when pelagic fish are scarce; they are also available close to rookeries.

(h) **Rock Lobster.**

A single juvenile rock lobster (*Jasus lalandii*) was recorded in a cormorant stomach during March. This record amounted to 1 per cent of the general diet of the cormorant by frequency and almost nil by weight.

Note on feeding of the cormorant away from St. Helena Bay.—From time to time cormorants were shot between Cape Columbine and Table Bay in order to find out the species of shoal fish present in the area.

During the year, cormorants in this area were found to have eaten pilchards and anchovies.

(ii) Comparison of Feeding for the First and Second Years.

The completion of a second year of research has confirmed the importance of the pilchard as a food organism of the cormorant in the St. Helena Bay area, and has in addition shown that the general diet of the cormorant is less restricted than was previously thought. While maasbankers, anchovies and rock lobsters were eaten during both

* These percentages refer only to those cormorants which had eaten maasbankers.

years, one species of fish (*Paralepis* sp.) was found in stomachs during the first year and was not found in the second. The new records were the hottentot (*Pachymetopon blochii*), the Klipfish (*Clinus* spp.) and the shrimp (*Palaemon pacificus*). The fish *Paralepis* sp. was found in stomachs of birds shot in Table Bay during the first year, but no cormorants were obtained in this area during the second year.

Pilchards were eaten to the same extent in both years and were the most important food organism of the cormorant in the St. Helena Bay area.

Anchovies were eaten to a lesser degree during the second year, but were still second in importance as food organisms.

Klipfish were found to have been eaten by cormorants during the second year and not the first, the reason being that more birds were shot close inshore in the second year.

Maasbankers were less important as food organisms during the second year and decreased from 20 per cent to 11 per cent by frequency and from 10 per cent to 5 per cent by weight.

The new record of the hottentot as a food organism may be due to the fact that more cormorants were obtained close inshore than in the previous year.

The new record of the shrimp as a food organism is also considered to be due to the fact that cormorants were shot closer to the shore than previously.

Only one juvenile rock lobster was recorded during March of the second year whereas in the previous year larger numbers were found during January and February.

On the basis of two years data on *the feeding of the cormorant in the St. Helena Bay area, it may be said that the most important food organism is the pilchard. The majority of pilchards eaten are of commercial size.* The other organisms eaten *include maasbankers, a very small percentage of which consist of fish of commercially-exploitable size.* The remaining food organisms are of little significance in relation to the commercial fisheries, (the only exception being the rock lobster which is not important in the diet of the cormorants of the St. Helena Bay area).

(iii) Digestion and Food Capacity.

Digestion experiments similar to those carried out on the gannet were done on the cormorant. For convenience and because the experiments were not identical in every detail for both species, a description of the procedure has been given.

Six live adult cormorants were obtained from Table Bay and placed in an enclosure away from any disturbance and provided with running sea water. They were given food in the form of live harders and allowed 24 hours in which to settle down. Each bird was then placed in a large basket separately in subdued light away from any disturbance and given no food for twelve hours.

The following procedure was then adopted:—

Live harders were caught from an aquarium tank, stunned, measured and weighed. In one case the volume was taken by displacement of water in a measuring cylinder. Groups of varying numbers of fish from 1 to 30 were then force-fed to the cormorants (see Table 8). After each fish had been introduced, a small amount of sea water was squirted down the cormorant's gullet in order to provide lubrication and because feeding cormorants were frequently observed swallowing water after having caught and swallowed fish.

Every effort was made to disturb the bird as little as possible while force-feeding was in progress. A cloth held carefully over the eyes during the process caused the bird to remain quiet. While some birds tended to regurgitate violently as soon as food was introduced, others swallowed easily. Of the four birds used for the digestion time experiments, one refused to retain its food (see Table 8), but with the aid of rubber bands slipped over their beaks, the other three cormorants retained their fish.

A single fish was given to the first bird and allowed to remain in its stomach for a period of 30 minutes, after which it was killed and its stomach contents examined, weighed and the volume measured. The fish was found to have disappeared entirely from the stomach except for a few small bones and scales which remained behind in the posterior end of the stomach.

For the second and third cormorants, the same amount of fish was weighed out and force-fed to the birds and allowed to remain in the stomach for periods of one and two hours respectively. Each bird was then killed and the stomach contents examined and weighed. For the second bird, which was killed after one hour, approximately 45 per cent of the food organisms, i.e. the two harders in the posterior end of the stomach, had left the stomach and moved on to the intestine,

while the remainder were softened but otherwise unchanged. In the third bird, which was killed after two hours, 89 per cent of the fish had left the stomach and only hard parts such as scales, parts of fins, eyeballs and bones remained (see Table 8).

It is evident therefore that *the time taken for the evacuation of the stomach depends to a large extent on the state of repletion of the cormorant, but that the initial digestion of the soft parts of fish is rapid.*

The hard parts may take a considerable time to become completely digested but probably move from the stomach to the intestine more rapidly if pressure in the form of the addition of food organisms by further eating takes place.

The fifth cormorant was killed, its stomach and oesophagus immediately removed and their capacity found by means of distension by water as described for the gannet [see section 4 Part (iv)]. Three readings by this method gave a mean cubic capacity of 275 cc. The sixth cormorant was treated in the same way and the mean cubic capacity of its stomach and oesophagus from three readings found to be 269 cc. The sizes of these two birds as indicated by their weights were not widely different, viz. 2 lb. 3 oz. and 2 lb. 1 oz. respectively.

The maximum weight of fish recorded in a cormorant's stomach and oesophagus during the year was 283 gm. This is equivalent to a cubic capacity of about 283 cc. It is likely that the average capacity of the stomach and oesophagus of this species is in the neighbourhood of the mean capacity obtained by the water method and the highest capacity recorded in the birds shot at sea. *The mean total capacity of the oesophagus and stomach of the cormorant is therefore* 276 *cc, or* 276 *gm, i.e. approximately* 10 *oz.*

As these experiments on the digestion of the cormorant and its food capacity were carried out under laboratory conditions, the results obtained should be treated with some caution. It is nevertheless felt that the results provide a good basis for the discussion of feeding in general.

(iv) Cormorant Counts in St. Helena Bay.

Due to the fact that no figures of any kind were available for the numbers of Cape cormorants in the St. Helena Bay area, a system of regular counting of individual birds was devised. Full advantage was taken of the habit of cormorants of flying past Shell Bay Point (see Fig. 1) in the mornings from their rookeries and resting places in the south on their way to the fishing grounds in St. Helena Bay.

Their general behaviour on most days of the year was the same, although it was modified from time to time due to such factors as the movement or disappearance of the fish shoals, the migration and breeding activities of the cormorants and adverse meteorological conditions including fog, high winds and other factors such as heavy swell, which made fishing impossible.

During normal conditions when the weather was good and fish were present in the bay, flights of cormorants began to pass Shell Bay Point in a direction roughly from south to north from shortly after daybreak onwards. The flights varied in size from two to over a thousand individuals but were most often comprised of some hundreds of birds. The fact that flights invariably consisted of extended lines or formations of birds more or less evenly spaced made counting possible, and the following procedure was adopted:—

Never less than once a week and on an average nearly five times a month over a period of 2 years, one of the biologists stationed at the field station at Stompneusbaai, went to Shell Bay Point before first light and took up a position on top of a large sand-dune situated at the Point. He was equipped with a pair of field glasses (size 7 × 50) and a stopwatch.

General observations on the prevailing weather conditions were made including the type and amount of cloud, wind direction and approximate strength, and visibility in relation to haze or fog. The time was taken from when the first cormorants appeared until the last cormorant had passed.

As soon as a flight of cormorants appeared the observer pressed the stopwatch and at the same time counted the number of individuals which flew past in say five seconds, thereby obtaining a figure of cormorant density against time. Then for similar flights this procedure was used in conjunction with actual counting and totals jotted down for each flight. By means of actual counts for the smaller flights and stopwatch counts for the large extended flights results of considerable accuracy were obtained. It was found that weather conditions had a marked effect on the cormorants and their movements. For example, dull, overcast weather which cleared later caused them to start out later in the morning and strong winds prevented them from flying altogether.

Counts were made from November, 1953 onwards and in addition to the overall counts the numbers of separate flights and the average number of cormorants per flight were counted, (see Table 9 and Plate 5).

These counts are not necessarily indicative of the total number of cormorants feeding in St. Helena Bay. They do, however, represent the majority of cormorants in the area because, from extensive observations over a period of years, it is known that most of the cormorants which feed in St. Helena Bay come from roosting places and rookeries between Shell Bay Point and Saldanha Bay. Roosting places are also to be found between Shell Bay Point and Steenberg's Cove and between Steenberg's Cove and Cape Deseada, but these—mainly rocks and exposed reefs—do not accommodate very large numbers of birds (see later section on count between Shell Bay Point and Cape Deseada).

Because the counts made at Shell Bay Point represent the majority of cormorants in the area, their seasonal fluctuations are of considerable importance and the highest counts obtained, when taken in conjunction with counts in the remaining area of St. Helena Bay, are considered to be an accurate reflection of the total number of cormorants operating in the commercial fishing area.

The seasonal fluctuations in the numbers of cormorants as shown by the counts are clearly demonstrated when the monthly values of the highest counts or mean counts are compared (see Table 9) and striking maxima are seen in the Graph (see Plate 5).

During the two-year period, *the largest numbers of cormorants were recorded during winter and the smallest numbers in summer.*

The reason for the winter maximum counts is doubtless the fact that during this season the largest numbers of shoal fish are present in St. Helena Bay. The summer minimum counts are due to the absence of cormorants from the feeding area due to breeding activities.

Fairly high counts were also obtained during spring 1954, autumn 1955 and spring 1955, due perhaps to the presence of large numbers of fish in the area.

The highest single count during the two years was obtained in perfect weather conditions during June, 1955 *and amounted to* 41,113 *cormorants.*

Notes on cormorant count between Shell Bay Point and Cape Deseada.—During the early part of October, 1954 it was noticed that very few cormorants were engaged in fishing operations in St. Helena Bay. Although shoal fish were generally scarce, small numbers of pilchards were caught by the research vessels in shallow water in the northern part of the bay.

Instead of the usual morning flight from roosting places to fishing grounds, cormorants remained at their roosting places until after eleven o'clock in the morning. It was thought that this unusual behaviour was due to both the scarcity of shoal fish and the excessively dull, overcast weather experienced at the time.

Full advantage was taken of this situation and with the use of the fisheries research vessel " Schipa" a count was made of all resting cormorants along the coast between Cape Deseada and Shell Bay Point.

Shortly after sunrise on 10th October the vessel was brought in as close to land as possible at Cape Deseada and proceeded slowly towards the south. With the aid of binoculars, counts were made of all Cape cormorants seen roosting on the rocks, standing on the beaches or swimming in the surf amongst the unusually small waves encountered on that day.

As the sea was particularly calm it was possible to go very close to the shore and consequently the correct identification of the cormorants and the counting presented no difficulties.

Between Cape Deseada and Steenberg's Cove a total count of 6,140 cormorants was obtained and between Steenberg's Cove and Shell Bay Point 3,580 birds, *making a total between Cape Deseada and Shell Bay Point of* 9,720 *cormorants.* These counts took until early afternoon.

During the afternoon a special cruise to a point approximately in the centre of the bay was carried out in order to see if cormorants were feeding. Apart from one or two isolated individuals seen flying or sitting on the water, no cormorants were seen. On the return journey to Stompneus a detour was made so that the vessel travelled close to the coast for a considerable distance. The large concentrations of cormorants seen during the morning were still either sitting on the rocks or resting on the sand and none appeared to have left up till dusk.

By great good fortune, the morning of the following day was bright and clear and a routine count of cormorants moving northwards past Shell Bay Point was made which gave a total of 16,154 birds. It seems therefore that the total number of cormorants operating in the St. Helena Bay area is made up of the sum of the total counts from Cape Deseada to Shell Bay Point and the routine count at Shell Bay Point made on the 11th October, i.e. 25,874 cormorants, these two counts representing the birds which normally roost on the fringes of St. Helena Bay and those which roost south of Shell Bay Point and fly northwards to the bay to feed.

This total of 25,874 cormorants operating in St. Helena Bay is by no means a maximum figure. While the count between Cape Deseada and Shell Bay Point is probably a fairly accurate maximum for this particular section, the October routine Shell Bay Point maximum is by no means the highest count obtained.

In order to obtain a maximum figure for the routine counts it is considered reasonable to use the mean of the two highest counts recorded in the month of June in both years, i.e. 23,035 and 41,113 cormorants which gives a mean of 32,074 birds.

The maximum figure for the number of Cape cormorants operating in St. Helena Bay then becomes 32,074 plus the total number recorded between Cape Deseada and Shell Bay Point, i.e. 9,720, *which gives a grand total of* 41,794 *cormorants.*

The average figure for the number of Cape cormorants operating in St. Helena Bay may be taken as the mean of the highest counts obtained for the two years at Shell Bay Point (see Table 9) i.e. 10,242 and the total count for the remainder of St. Helena Bay, i.e. 9,720 *which gives an overall average figure of approximately* 20,000 *cormorants.*

(v) Discussion.

The cormorant population of the West coast region of the Union concentrated in the St. Helena Bay—Saldanha Bay area feeds mainly on pelagic shoal fish. The fish which is eaten in greatest quantity is the pilchard and this species forms the mainstay of the cormorant population of this area. The majority of pilchards eaten by cormorants are fish of commercially-exploitable size. Anchovies are next in importance to the pilchard but are eaten to a much lesser extent. Maasbankers are eaten seasonally, but are not of great importance to the cormorants of this area.

Other fish eaten by the cormorants in the area are the klipfish and the hottentot, but it is considered that these two species are only of incidental importance.

Invertebrates eaten include shrimps and juvenile rock lobsters and although the latter is a most important commercial species, neither of these crustaceans is considered to be of very great importance in the feeding of the cormorant in the St. Helena Bay area.

In a previous estimate of the consumption of food by cormorants it was estimated that their capacity was in the neighbourhood of 1 lb. (Davies 1955). It is now considered, after further experiment [see section (iii)] that the average capacity of the cormorant is less than 1 lb. and is approximately 10 oz. From extensive observation it has been established that when food organisms are available, the cormorant feeds until it is replete, after which it rests on the water until a certain amount of digestion has taken place and then begins feeding again. The reason for this lies almost certainly in the fact that as soon as partial evacuation of the stomach is effected by the process of digestion, contractions begin in the empty part of the stomach causing a sensation of hunger which causes the bird to start feeding again. The occurrence of these contractions has been established for the domestic fowl and the goose (Dukes, 1947) and there is little doubt that they occur in all birds.

On the same time basis as before, viz. an average of 10 hours of daylight during which cormorants can fish all the year round, and taking $1\frac{1}{2}$ hours for searching for prey, 1 hour for fishing and allowing $2\frac{1}{2}$ hours for sufficient digestion for evacuation of the stomach to enable the bird to swallow another meal, gives a total of 5 hours for the complete operation. In 10 hours, therefore, two complete feeding operations involving a total food consumption of 1 lb. 4 oz. will be completed.

It may be mentioned that from the observation of feeding cormorants at times when shoal fish were plentiful, it appeared that considerably more than two such operations were carried out during a day and, in fact, far more fish was probably consumed. Cormorants were seen to feed actively for a period, then rest in rafts for periods of about 30 minutes and then return to the shoal and actively fish again, continuing on these lines from dawn to dusk. When lean periods are taken into account, however, the above total daily food consumption of 1 lb. 4 oz. is probably not unreasonable.

As in the case of the gannet, let us assume that a cormorant feeds successfully for only two-thirds of the year, the other third being taken as non-feeding time due to bad weather (2 months), non-availability of fish (1 month) and breeding activities (1 month). Then 1 lb. 4 oz. will have been eaten daily for 244 days, making a total of 305 lb. consumed per year. Of this, 300 lb. may be taken as consisting of fish, and the remaining 5 lb. of crustaceans.

Taking the average figure of 20,000 *cormorants feeding in St. Helena Bay (see previous section) at the rate of* 300 *lb. per bird per year a total of approximately* 3,000 *tons of fish is eaten per year. Of this amount approximately* 1,500 *tons are pilchards and approximately* 250 *tons are maasbankers. Of the* 1,500 *tons of pilchards eaten,* 1,000 *tons are of a size normally caught commercially, and of the* 250 *tons of maasbankers eaten,* 60 *tons are of commercially-exploitable size.*

If the maximum figure for cormorants feeding in St. Helena Bay, i.e. 41,794 birds, is used then the total tonnage of fish consumed becomes more than doubled.

5. The Cape Penquin.

(i) The Food of the Penguin.

The results of the previous year's study of the feeding of the Cape penguin were based on the examination of the stomachs of penguins obtained during three months only (see previous report) and really only served to illustrate the diversity of the diet of the penguin during the summer months.

During the second year, however, penguins were shot in every month of the year and the examination of the stomach contents of 112 birds showed that their food consisted of the following:—

(*a*) Pilchard, *Sardinops ocellata* (Pappe).

(*b*) Anchovy, *Engraulis japonicus* (Houttuyn).

(*c*) Maasbanker, *Trachurus trachurus* Linn.

(*d*) Mackerel, *Scomber japonicus* Houttuyn.

(*e*) Fish remains, unrecognisable.

(*f*) Squid, *Loligo reynaudi.*

(*g*) Crab larvae.

(a) Pilchard.

Pilchards were found to make up 39 per cent of the food of the penguin by frequency and 58 per cent by weight, (see Tables 11 and 12, Plate 7, Figs. 1 and 2).

Pilchards were found mixed with anchovies or maasbankers in penguin stomachs. The numbers of pilchards per stomach varied from 1 to 52 and depended on the size of fish caught. The mean length of pilchards eaten was 17·8 cm and the range 5·5–26·7 cm. It was found that 57 per cent* of penguins had eaten pilchards under 12 cm and 43 per cent* over 20 cm in length. The smaller sizes of pilchard were eaten during April, June, January and February, while those over 20 cm were eaten during May, July, August, September and October.

The greatest weight of pilchards found in a single stomach was 252 gm.

The pilchard is the most important food organism of the penguin in the St. Helena Bay area and although the majority of pilchards eaten were fish below the size of the fish in the commercial catches, over forty per cent of penguins had eaten commercially-exploitable pilchards.

Pilchards were eaten during every month of the year except February.

(b) Anchovy.

Anchovies were found to make up 35 per cent of the food of the penguin by frequency and 28 per cent by weight, (see Tables 11 and 12 and Plate 7, Figs. 1 and 2).

Anchovies were found mixed with pilchards. The numbers of anchovies per stomach varied from 1 to 200 and consisted of fish of length range 4·3–13·5 cm. The mean length of anchovies eaten was 9·8 cm, i.e. the majority were young fish.

Anchovies were eaten during autumn, late winter, spring and summer, during March, April and August through to February.

(c) Maasbanker.

Maasbankers were found to make up 2 per cent of the food of the penguin by frequency and 3 per cent by weight (see Tables 11 and 12 and Plate 7, Figs. 1 and 2).

Maasbankers were found mixed with pilchards. The number of maasbankers varied from 1 to 4 and

* These percentages refer only to those penguins which had eaten pilchards.

consisted entirely of small fish of approximate length 7·5 cm.

Maasbankers were eaten during April, November and February only (see Plate 6, Figs. 1 and 2).

The maasbanker is an organism of minor importance in the food of the penguin in the St. Helena Bay area.

(*d*) **Mackerel.**

Mackerel made up approximately 1 per cent of the food of the penguin by frequency and less than 1 per cent by weight (see Tables 11 and 12).

Two mackerel of unknown size were found in the stomach of a single penguin obtained during November.

This recording merely indicates the presence of small mackerel (a penguin could not eat a large one) in the area at the time, and that when available, mackerel of suitable size may be eaten.

(e) **Fish remains.**

Fish remains were obtained in penguin stomachs during the year but due to advanced digestion could not be identified.

(*f*) **Squid.**

Squid were recorded in the stomachs of penguins for the first time, and constituted 2 per cent of the food of the penguin by frequency and by weight.

In no case was more than one squid found in the stomach of a penguin. All squids found were of the same species. They were recorded in stomachs during March, January and February, and may be of some importance as food organisms of the penguin during times when shoal fish are scarce or as food easily available near the rookeries.

(*g*) **Crab larvae.**

Crab larvae were found in the stomach contents of a penguin during August only, and made up 1 per cent of the food of the penguin by frequency and 2 per cent by weight.

A total of twenty-seven crab larvae, megalopa stages of *Plagusia chabrus*, were found in the stomach of this penguin which was shot close to the shore.

Crab larvae were recorded during the year for the first time and may be important as an incidental food organism available seasonally in the vicinity of the rookeries.

Note on feeding of the penguin away from St. Helena Bay.—From time to time penguins were shot between Cape Columbine and Table Bay in order to find out the species of shoal fish present in the area.

They were found to have eaten pilchards, maasbankers, anchovies and sandcords, *Gonorhynchus gonorhynchus* (Linn).

(ii) Comparison of Feeding for the First and Second Years.

As the previous study on the feeding of the penguin was based on material collected during three months only, and the present study on material collected over a year, a full comparison is not possible.

During December, January and February, i.e. the summer, pilchards were eaten very extensively during both years.

More maasbankers were eaten during this season in the first year than in the second, but were not the dominant food organism in either year.

Anchovies were eaten in small numbers in February of the first year but large numbers were found in stomachs during all seasons of the second year.

Mackerel were eaten in small quantities during December of the first year and November of the second year.

Harders and rock lobsters were eaten during the first year in January but were not eaten at any time during the second year.

Squid and crab larvae were recorded for the first time during the second year.

(iii) Digestion and Food Capacity.

Digestion experiments similar to those carried out on the gannet and cormorant were done on the penguin. For convenience and because of minor differences in the experiments, a detailed description of the procedure is given.

Five adult penguins were obtained alive from Dassen Island and placed in an enclosure away

from any disturbance and provided with running sea water. They were fed with live harders and allowed 24 hours in which to settle down. Each bird was then placed in a large basket separately in subdued light away from any disturbance and given no food for 12 hours.

The following procedure was then adopted:—

Freshly caught pilchards were weighed and measured, and, because they were large, were cut up into sections. These were force-fed to each of three penguins, the same weight of fish being given to each penguin. Between the introduction of successive pieces of fish a small quantity of sea water was squirted down the penguin's throat in order to help swallowing and to reproduce the normal habit of penguins when feeding.

A cloth held over the penguins' eyes caused them to remain passive during the feeding operations. The reaction of individual birds to force-feeding was different. The first bird, which, although adult, weighed less than half the others, swallowed the fish as soon as it was placed in its gullet. The others offered considerable resistance at first but later swallowed the pieces of fish. It was found unnecessary to place rubber bands on the penguins' beaks after feeding as no regurgitation took place once they had swallowed the fish.

The equal amounts of fish fed to the three penguins were examined and re-weighed after the birds had been killed at intervals of two, three and four hours (see Table 12).

After two hours the stomach contents were very soft and had begun to disintegrate at the posterior end where green discolouration occurred. During one hour 46 gm of material had disappeared from the stomach.

After three hours 49 per cent of the stomach contents had moved on to the intestine and the material which remained was pure mush.

After four hours most of the food material had disappeared from the stomach of the penguin and the small amount of material left in the posterior end of the stomach was made up of scales, bones and other hard material.

After four hours the stomach is three-quarters evacuated but feeding probably starts again long before this stage is reached.

The remaining two penguins were killed, the stomach and oesophagus removed and their cubic capacity found by mechanical distension by water as described for the gannet [see section 4, part (iv)]. Three readings for each bird gave a mean capacity of 800 cc and a maximum mean distended capacity of 1,000 cc. The sizes of the two penguins were similar (their weights were 8 lb. 3 oz. and 8 lb. 5 oz. respectively).

The maximum weight of fish recorded in a penguin's stomach during the feeding studies was 812 gm which is equivalent to a capacity of about 812 cc. It is important to note that this capacity refers to the stomach only and that the contents consisted of well digested small fish. The total possible intake of an adult penguin may therefore be well over 812 gm and closer to 1,000 gm.

The mean capacity of 800 *cc or about* 800 *gm or* 1*lb.* 12 *oz. obtained by water distension is therefore considered to be a fair, if not conservative, average for a full meal for an adult penguin.*

(iv) Discussion.

The penguins of the St. Helena Bay area feed almost entirely on fish. Pilchards are eaten in greatest quantity but less than half are of commercially-exploitable size, i.e. the majority are small fish.

Anchovies are second in importance to the pilchard in the food of the penguin while maasbankers and mackerel together with squid and crab larvae are of little significance as food organisms in this area.

From the previous section it is seen that the average capacity of the penguin is approximately 1 lb. 12 oz. Observations on the feeding of penguins are difficult, but it is likely that they feed until replete, rest during the early stages of digestion and then begin feeding again as soon as the sensation of hunger returns due to contractions caused by partial evacuation of the stomach.

The feeding of the penguin is different from that of either the cormorant or the gannet (apart from the method of feeding which is carried out without the advantage of flight) because of its protracted breeding activities. Breeding may take place during spring, summer, autumn and even winter. Penguins, when at sea, do not normally congregate in large numbers but move about in pairs or small groups of up to a dozen individuals. When shoal fish are present, however, numbers of groups come together and form much larger congregations.

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From general observations it appears that penguins remain on land for long periods for breeding, during which little feeding takes place other than casual fishing from time to time in the immediate vicinity of the islands. Then they go to sea on definite feeding expeditions with a view to building up fat reserve for further spells ashore. The feeding of penguins in St. Helena Bay is therefore difficult to assess.

Whenever a shoal of fish near the surface is being worked by gannets and cormorants, penguins are invariably present. The numbers of penguins present have always been observed to be far less than the other two species and from counts taken at various times during the year appear to be present in the proportion of about one quarter of the cormorants feeding.

If the average number of cormorants feeding in St. Helena Bay is 20,000, then the average number of penguins feeding in the bay would be roughly 5,000 birds.

On the same basis as that used for both cormorants and gannets (i.e. an average of 10 hours of daylight all the year round, an allowance of $1\frac{1}{2}$ hours for searching for prey, 1 hour for fishing and $2\frac{1}{2}$ hours for sufficient digestion for evacuation of the stomach to enable the bird to begin on the next meal, thus giving a total of 5 hours per feeding operation) two complete feeding operations involving a total food consumption of 3 lb. 8 oz., will have been completed in 10 hours.

Let us assume that the comparatively small number of penguins fishing in St. Helena Bay are successful for only two thirds of the year, the other third being taken as non-feeding time due to bad weather (2 months), non-availibility of fish (1 month), breeding activities (1 month), then 3 lb. 8 oz. will be eaten per bird per day for 244 days, making a total of 854 lb. consumed per year.

Taking the figure of 5,000 *penguins feeding in St. Helena Bay at the rate of* 854 *lb. per bird per year, a total of approximately* 2,000 *tons of fish is eaten per year. Of this amount approximately* 1,000 *tons consist of pilchards,* 700 *tons of anchovy and* 60 *tons of maasbankers. Of the* 1,000 *tons of pilchards eaten,* 450 *tons are of a size normally caught commercially.*

6. Birds as Indicators of Shoal Fish.

From the beginning of the pilchard/maasbanker research programme in 1950, considerable difficulties were experienced in the location and sampling of juvenile fish. Various methods, including the use of echo-sounding apparatus, nets, explosives and finally the blanket net, were used. Until the use of the latter in 1955, however, sampling of juvenile pilchards and maasbankers could only be described as haphazard. The blanket net as described by Radovich and Gibbs (1954), has now made regular sampling possible.

Prior to 1955, feeding birds such as gannets, cormorants and terns were found extremely useful in the location of fish during daylight operations, particularly with explosives. As a result, it became the practice to shoot one and sometimes two birds whenever large numbers were seen working on shoal fish. The birds' stomach contents were examined and the fish identified and measured. The position in latitude and longitude was also noted.

Birds were shot for the purpose of identifying the individuals comprising fish shoals between Lambert's Bay and Cape Point, but more particularly in Table Bay and in the vicinity of Robben and Dassen Islands.

It is of interest to record that the following identifications of fish shoals by this method were made:—

1954—

March—large-sized pilchards in the vicinity of Robben Island.

April—large-sized pilchards to the south of Saldanha Bay.

August—juvenile anchovies in the vicinity of Robben Island.

October—juvenile anchovies and pilchards in Table Bay.

1955—

May—juvenile maasbankers in very large shoals in Table Bay.

The above records are used to demonstrate the effectiveness of this method of locating and identifying fish shoals, but is not a complete record of the data obtained. All the data from this source will be incorporated in a later paper dealing with juvenile pilchards and maasbankers and their occurrence in relation to area and season.

It is hoped that when a suitable vessel can be spared from the routine research work carried out off the West coast, it will be possible to follow shoals

of fish moving past Cape Agulhas towards the East coast, carrying out regular sampling with a view to finding the connection between the West coast pilchard and the Natal sardine.

7. General Discussion.

A second year of investigations into the feeding of the sea-birds of St. Helena Bay has shown that the general diets of the gannets, cormorants and penguins in this area do not undergo major changes and are, in fact, limited to a few species of food organisms of which the pilchard is by far the most important.

The reason for the fact that these birds are concentrated in such large numbers in this area is without doubt due to the presence in great quantity of shoal fish such as the pilchards, maasbankers and anchovies. The fact that islands are conveniently situated in the vicinity can only be regarded as an attraction secondary to the presence of the shoal fish.

It is likely that the general diet of these birds becomes more varied in other areas which do not possess such an abundance of pelagic fish, but this is considered to be unimportant in relation to the two main areas of concentration, viz. St. Helena Bay in the Union and Walvis Bay in South West Africa. Careful investigation into the food of smaller yet important concentrations such as, for example, the gannets of Bird Island off Port Elizabeth would be of very great interest and may reveal the presence of small-sized pelagic fish in unexpected numbers.

Experiments on the digestion and food capacity of the birds showed that the gannet and penguin are capable of a remarkably high daily consumption of food. While *it has not been proved that gannets, cormorants and penguins eat more than one full meal a day*, from the evidence available it is almost certain. It is hoped that it will be possible to carry out observations on marked birds during daylight hours in order to establish the number of meals eaten per day. Physiological experiments on other birds have shown that the passage of food through the entire alimentary system can be extremely rapid. For example, the minimum time for oats to appear in the faeces after being fed to a domestic fowl was 5 hours (Dukes, 1947). Passage of food through the gastro-intestinal canal without actual defaecation took as little as 4 hours. It was further found that the sensation of hunger returned shortly after a meal, i.e. as soon as evacuation of the stomach began.

During the non-breeding season gannets were seen feeding actively on a shoal of fish after which they would rest while floating on the water for a short period (15–30 minutes) and then start fishing again. In this way, they maintained contact with the shoal throughout the day. During such times as these when no flying to and from the islands takes place, it is likely that very large quantities of fish are consumed.

For this reason the conception of an ideal fishing day based on an average of 10 hours of daylight and two meals per bird per day for two thirds of the year is not considered unreasonable. The allowance of 10 hours is conservative and the time of one third of a year allowed as non-feeding time is based on relevant meteorological data and also includes allowances for reproduction and scarcity of food organisms.

It is of interest to compare the estimated consumption of fish by the gannets, cormorants and penguins of the St. Helena Bay area for the two years of research. For the first year gannets and cormorants were estimated to have consumed 38,800 tons of pilchards and 12,550 tons of maasbankers. For the second year, however, this estimate was reduced to 32,000 tons of pilchards and 9,000 tons of maasbankers for the gannets, cormorants *and penguins* of the area, i.e. a reduction in consumption of 10,000 tons of fish in spite of the addition of the penguins. The main reason for this reduction is the fact that the estimated total number of gannets—the biggest consumers—in the area was reduced from 200,000 to 112,000 birds, in consequence of counts obtained on Malgas Island from a ground survey and aerial photographs (Rand, 1955). The discrepancy between this and the previous count (Broekhuysen and Rudebeck, 1951) is very large and has been assigned to the difference in the method of counting rather than a diminution in the numbers of birds. The increased guano yield for Malgas Island for 1954 (see below) indicates that a substantial *increase* in the gannet population took place during this year.

It is evident therefore that the main weakness in the assessment of the predation of these birds on fish lies in the lack of adequate census figures for the birds. This difficulty should be obviated in the near future by the large-scale aerial survey of all the bird islands off the Union and South West Africa to be undertaken by the Trigonometrical Survey before the end of 1955. It is hoped that the

census figures for gannets, cormorants and penguins in the St. Helena Bay area will give far greater value to the results already obtained, and coupled with the results of a third year of feeding studies should be of considerable significance.

It is of interest to consider the values of the commercial catches of pilchards and maasbankers in relation to the quantities of these fish consumed by birds, and the relative values of the bird products such as guano and eggs for a second year, viz. 1954.

The total catch for the Union of South Africa for 1954 was 93,790 tons of pilchards and 133,011 tons of maasbankers. The landed value of these together (taken at a rate of £4 per ton, whereas prices reached £4. 10s. 0d. per ton during the year) was approximately £910,000. The total value of this catch in terms of canned products, meal and oil was approximately £4,900,000. On this basis the 41,000 tons of pilchards and maasbankers eaten by the birds were worth £165,000 in terms of landed value and £890,000 in terms of final fishery products.

The total guano yield for the year 1954 was 5,734 tons, and the total number of penguin eggs collected was 148,248. The price realised for the guano, sold at £11. 15s. 0d. per ton, was £67,375 and the price obtained for the eggs was £4,633. Thus, for the year's guano and egg yield a total income of £72,008 was received. The cost of the production of the guano to the Guano Islands Division was £84,577 and of the penguin eggs £3,088. The sale of guano for 1954 showed a loss of £17,202 and the sale of penguin eggs showed a profit of £1,545. The loss on guano collection may, however, be regarded as fictitious as the sale of guano to the farmers can be considered to have been subsidised to the extent of £17,202. The real sales value of guano in the overseas market is as high as £50 per ton, which would give an income on the 1954 production of guano of £286,700 in place of £67,375.

Based on the analysis of the phosphorus content of fish and apparently not allowing for wastage etc., Hutchinson (1950) estimates that a consumption of at least 1,460,000 tons of fish by birds is required to produce an annual guano crop of 150,000 tons, i.e. 9·7 tons of fish give 1 ton of guano. It is therefore of interest to list the amounts of guano collected from the St. Helena Bay—Saldanha Bay area in order to calculate the amount of fish required for the production of guano on the above basis.

The amount of guano collected from this area during 1953 and 1954 was represented as follows:—

	1953.	1954.
	Tons.	Tons.
Penguin Islet, Lambert's Bay.....	278	232
Malgas Island.....	260	669
Jutten Island.....	345	157
Marcus Island.....	13	25
Vondeling Island.....	54	35
Dassen Island.....	646	597
TOTAL.....	1,596	1,715

Based on Hutchinson's estimate therefore, the amount of fish consumed in the St. Helena Bay area to produce 1,715 tons of guano obtained from the area in 1954 would be 16,635 tons. This figure is much less than the estimated total amount of fish consumed in the St. Helena Bay area for the first year (1953–54) which was 77,000 tons and the second year (1954–55) which was 60,000 tons.

It appears therefore that either Hutchinson's figures cannot be applied to South African conditions or that the estimates for St. Helena Bay are quite wrong. The real truth probably lies between these possibilities, but a final assessment of the fish consumed by the birds of St. Helena Bay cannot be made until accurate census figures of the numbers of birds present are available. This will be possible as soon as the aerial census has been carried out.

8. Recommendations.

In view of the fact that some doubt exists as to the numbers of gannets, cormorants and penguins feeding in the St. Helena Bay area, it is considered inadvisable to make any far-reaching recommendations at present, particularly as full census figures should be available for the final report on the predation of fish by sea-birds, which will be based on the data collected over the three year period March, 1953 to February, 1956.

Recommendations have therefore been reduced to a minimum, and are as follows:—

(1) That no steps be taken at present to control sea-bird predators off the West coast of South Africa.

(2) That further research be carried out in relation to the predation of sea-birds on fish, particularly in areas not investigated.

(3) That the question of research into the predation of sea-birds on fish in South West African waters be treated as a matter of urgency, particularly as the pilchard fishery centred at Walvis Bay is probably linked with that of the Union.

(4) That the whole question of the predatory sea-birds of the St. Helena Bay area and their relationship to commercial fisheries and guano production be reviewed during 1956 when adequate data should be available.

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TABLE 1.—THE FOOD OF THE CAPE GANNET.

Month.	Locality.	Surf. Temp.	Food Organism in Stomach.	Number of Birds in which Found.	Highest Number of organisms per Bird.	Total Number from all Birds.	Mean Total length of Food Organisms.	Total Weight of all Food Organisms.	Mean Weight per Organism.	Total Weight of all organisms at time of Eating.	Mean Weight per organism at time of Eating.	Number of Birds Shot.	Remarks.
1954.		°C					cm	gm	gm	gm	gm		
March.....	St. Helena Bay.	16	Pilchard.....	1	1	1	—	17·0	17·0	—	—	12	Very much digested.
			Maasbanker..	5	4	11	—	487·9	44·4	—	—		Too much digested for length measurement.
			Empty.....	6	—	—	—	—	—	—	—		Large maasbanker disgorged when one bird was shot.
April.....	St. Helena Bay.	14·5	Pilchard.....	10	4	27	24·3	2,526·7	93·6	3,537·0*	131·0*	14	Mainly slightly digested.
			Maasbanker..	2	1	2	29·0	319·1	159·5	470·0*	235·0*		One freshly eaten, the other well digested.
			Fish remains.	1	—	—	—	17·0	—	—	—		Unrecognisable.
			Empty.....	1	—	—	—	—	—	—	—		
May.....	St. Helena Bay.	15·8	Pilchard.....	2	2	3	24·8	160·5	53·5	414·0*	138·0*	2	One freshly eaten, two very well digested.
June.....	St. Helena Bay.	13·4	Pilchard.....	3	1	3	25·5	329·0	109·6	423·0*	141·0*	17	Adult pilchards.
			Pilchard.....	5	15	43	11·2	446·6	10·4	559·0*	13·0*		Juvenile pilchards in different stages of digestion.
			Fish remains.	6	—	—	—	277·2	—	—	—		Probably juvenile pilchards.
			Empty.....	3	—	—	—	—	—	—	—		
July.....	St. Helena Bay.	12·2	Pilchard.....	8	4	19	26·0	1,722·9	90·6	2,926·0*	154·0*	16	Different stages of digestion.
			Fish remains.	4	—	—	—	36·4	—	—	—		Unrecognisable.
			Empty.....	4	—	—	—	—	—	—	—		
August.....	St. Helena Bay.	13·3	Pilchard.....	36	7	111	26·1	11,148·1	100·4	17,316·0*	156·0*	54	Different stages of digestion.
			Maasbanker..	1	1	1	19·5*	63·2	63·2	63·2	63·2		Freshly eaten.
			Fish remains.	8	—	—	—	396·3	—	—	—		Unrecognisable.
			Empty.....	11	—	—	—	—	—	—	—		
	Saldanha Bay..	11·4	Anchovy.....	8	20	56	12·5	562·1	10·0	728·0*	13·0*	15	Mainly well digested.
			Fish remains.	3	—	—	—	67·9	—	—	—		Unrecognisable.
			Empty.....	4	—	—	—	—	—	—	—		
September....	St. Helena Bay.	13·4	Pilchard.....	3	3	6	25·8	436·6	72·8	900·0*	150·0*	11	Well digested.
			Maasbanker..	3	3	6	29·5	539·1	84·8	1,380·0*	230·0*		Well digested.
			Anchovy.....	1	10	10	12·3	83·1	8·3	110·0*	11·0*		Slightly digested.
			Harder.....	1	2	2	25·0	287·0	143·5	287·0	143·5		Freshly eaten.
			Fish remains.	3	—	—	—	53·5	—	—	—		
October.....	St. Helena Bay.	12·9	Pilchard.....	10	5	21	25·0	2,202·6	104·9	2,835·0	135·0*	12	Different stages of digestion.
			Anchovy.....	1	—	—	—	54·0	—	—	—		Very much digested.
November....	St. Helena Bay.	12·3	Pilchard.....	1	1	1	10·1	6·5	6·5	12·0*	12·0*	3	Well digested.
			Anchovy.....	2	1	2	9·0	12·1	6·1	16·0*	8·0*		Well digested.
			Fish remains.	2	—	—	—	19·5	—	—	—		Unrecognisable.
December.....	St. Helena Bay.	16·6	Pilchard.....	1	1	1	27·8	173·5	173·5	180·0*	180·0*	8	Partly digested.
			Maasbanker..	1	2	2	—	174·0	87·0	—	—		Very much digested.
			Anchovy.....	6	15	—	± 7·0	498·2	—	—	—		Very much digested.
1955.													
January.....	St. Helena Bay.	14·9	Pilchard.....	10	35	± 170	10·0	1,847·0	± 10·0	2,040·0*	12·0*	15	Juveniles in different stages of digestion.
			Pilchard.....	1	5	5	21·0	335·0	67·0	600·0*	120·0*		Larger fish, much digested.
			Anchovy.....	2	2	3	11·0	30·0	10·0	30·0*	10·0*		Freshly eaten.
			Mackerel....	1	1	1	14·0	11·5	11·5	11·5	11·5		Freshly eaten.
			Empty.....	1	—	—	—	—	—	—	—		
February.....	St. Helena Bay.	14·6	Pilchard.....	5	30	56	10·5	515·5	9·2	700·0*	12·5*	12	Juveniles, partly digested.
			Maasbanker..	2	2	4	9·5	35·0	8·8	40·0*	10·0*		Juveniles, slightly digested.
			Anchovy.....	4	5	12	12·0	148·8	12·4	150·0*	12·5		Juveniles, freshly eaten.
			Fish remains.	5	—	—	—	207·5	—	—	—		Unrecognisable.
			Empty.....	1	—	—	—	—	—	—	—		
											Total.	191	

* Calculated from available data.

TABLE 2.

PERCENTAGE FREQUENCY OF FOOD ORGANISMS OF THE CAPE GANNET.*

Month.	Pilchard.	Maasbanker.	Anchovy.	Mackerel.	Harder.	Fish Remains.
1954—	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
March	8	42	—	—	—	—
April	71	15	—	—	—	7
May	100	—	—	—	—	—
June	47	—	—	—	—	35
July	50	—	—	—	—	25
August	67	2	—	—	—	15
Saldanha	—	—	53	—	—	20
September	27	27	9	—	9	27
October	83	—	8	—	—	—
November	33	—	66	—	—	66
December	13	13	74	—	—	—
1955—						
January	73	—	13	7	—	—
February	42	17	33	—	—	42

* Calculated from columns 5 and 13 of Table 1.

TABLE 3.

MEAN TOTAL ESTIMATED WEIGHT OF FOOD ORGANISM PER BIRD.*

Month.	Pilchard.	Maasbanker.	Anchovy.	Mackerel.	Harder.	Fish Remains.
1954—	gm	gm	gm	gm	gm	gm
March	17†	98†	—	—	—	—
April	354	235	—	—	—	17†
May	207	—	—	—	—	—
June	123	—	—	—	—	46†
July	366	—	—	—	—	4†
August, Saldanha	481	63†	91	—	—	42†
September	300	460	110	—	287	18†
October	284	—	54†	—	—	—
November	12	—	8	—	—	10†
December	180	174†	83†	—	—	—
1955—						
January	240	—	15	12	—	—
February	140	20	38	—	—	42†

* Calculated from columns 5 and 11 of Table 1.

† Calculated from actual weights.

Table 4.

The Digestion of the Cape Gannet.

Bird Number.	Food Organism.	Number Fed.	Mean total Length.	Total weight at Time of Feeding.	Total weight after Period of Digestion.	Difference.	Total volume at Time of Feeding.	Total volume after Period of Digestion.	Difference.	Time allowed for Digestion.	Weight of Bird.	Remarks.
			cm	gm	gm	gm	cc	cc	cc	hrs. mins.	lb. oz.	
1	Harder..	3	25·5	345	241	104 (30%)	339	228	111	1 —	5 —	Soft parts mush.
2	Harder..	3	23·2	294	191	103 (35%)	292	178	114	2 —	5 5	Soft parts mush.
3	Harder..	3	19·9	220	110	110 (50%)	208	108	100	3 —	4 7	Soft parts mush.
4	Harder..	3	24·4	313	—	—	316	—	—	—	4 4	Fish regurgitated.
5	Harder..	6	10·0	78	46	32 (41%)	—	—	—	2 —	4 10	Soft parts mush.

Table 5.—The Food of the Cape Cormorant.

Month.	Locality.	Surf. Temp.	Food Organism in Stomach.	Number of Birds in which Found.	Highest Number of organisms per Bird.	Total Number from all Birds.	Mean Total length of Food Organisms.	Total Weight of all Food Organisms.	Mean Weight per Organism.	Total Weight of all organisms at time of Eating.	Mean Weight per organism at time of Eating.	Number of Birds Shot.	Remarks.
1954.		°C					cm	gm	gm	gm	gm		
March.....	St. Helena Bay.	13·5	Pilchard.....	1	2	2	—	15·3	7·7	—	—	8	Very much digested.
			Rock Lobster	1	1	1	—	—	—	—	—		Juvenile.
			Klipfish.....	3	7	17	—	187·0	11·0	—	—		Juveniles.
			Fish remains.	2	—	—	—	42·3	—	—	—		Unrecognisable.
			Shrimps.....	1	—	—	—	13·4	—	—	—		Much digested.
			Empty.....	1	—	—	—	—	—	—	—		
April.....	St. Helena Bay.	13·3	Pilchard.....	1	—	—	—	46·0	—	—	—	2	Very much digested.
			Fish remains.	1	—	—	—	11·0	—	—	—		Unrecognisable.
May.....	St. Helena Bay.	15·3	Pilchard.....	2	1	2	25·4	253·2	126·6	280·0*	140·0*	3	Slightly digested.
			Empty.....	1	—	—	—	—	—	—	—		Cormorants rare in the area.
June.....	St. Helena Bay.	13·6	Empty.....	1	—	—	—	—	—	—	—	1	Cormorants rare in the area.
July.....	St. Helena Bay.	12·2	Fish remains.	5	7	—	5·0	80·4	—	—	—	6	Probably klipfish.
			Empty.....	1	—	—	—	—	—	—	—		Cormorants rare in the area.
August.....	St. Helena Bay.	11·9	Anchovy.....	2	10	11	8·0	58·5	5·3	82·5*	7·5*	2	Well digested.
													Cormorants rare in the area.
September....	St. Helena Bay.	13·3	Pilchard.....	5	2	6	25·8	618·4	101·4	888·0*	148·0*	14	Mainly well digested.
			Pilchard.....	1	3	3	5·5	19·5	6·5	19·5	6·5		Juveniles, freshly eaten.
			Maasbanker..	2	1	2	23·7	197·4	98·7	260·0*	130·0*		Slightly digested.
			Anchovy.....	6	120	180	8·0	555·8	3·1	1,350·0*	7·5*		Much digested.
			Klipfish.....	2	25	29	—	107·3	4·3	—	—		Juveniles.
			Fish remains.	1	—	—	—	15·2	—	—	—		Cormorants plentiful.
October.....	St. Helena Bay.	13·1	Pilchard.....	14	3	25	25·3	2,552·6	102·1	3,450·0*	138·0*	18	Different stages of digestion.
			Maasbanker..	4	1	4	—	—	—	—	—		Very much digested.
			Anchovy.....	4	30	60	9·5	218·7	3·7	624·0*	10·4*		Mainly well digested.
			Fish remains.	1	—	—	—	20·0	—	—	—		Unrecognisable.
			Shrimp.....	3	7	12	—	17·0	1·4	—	—		
November....	St. Helena Bay.	12·9	Maasbanker.	1	1	1	—	32·8	32·8	—	—	9	Much digested adult.
			Maasbanker.	3	2	3	6·0	8·2	2·4	15·0*	5·0*		Much digested juveniles.
			Klipfish.....	1	2	2	6·0	10·3	5·1	—	—		Juveniles.
			Hottentot....	1	1	1	6·8	4·1	4·1	—	—		Juvenile.
			Fish remains.	8	—	—	—	139·9	—	—	—		Unrecognisable.
			Shrimp.....	1	1	1	—	1·3	1·3	—	—		
December.....	St. Helena Bay.	16·1	Empty.....	1	—	—	—	—	—	—	—	1	Very few birds seen in area.
1955.													
January.....	St. Helena Bay.	14·6	Pilchard.....	5	20	55	8·5	360·0	6·6	495·0*	9·0*	8	Juveniles mainly slightly digested.
			Klipfish.....	1	10	10	8·0	32·0	3·2	—	—		Juveniles well digested.
			Fish remains.	2	—	—	—	21·0	—	—	—		Unrecognisable.
February.....	St. Helena Bay.	15·5	Pilchard.....	4	29	58	9·0	277·7	4·7	5,510·0*	9·5*	5	Much digested.
			Maasbanker..	2	1	2	7·0	11·6	5·8	—	—		Juveniles much digested.
			Anchovy.....	1	9	9	11·5	91·0	10·1	—	—		Freshly eaten.
			Fish remains.	1	—	—	—	50·0	—	—	—		Unrecognisable.
											Total.	77	

* Calculated from available data.

Reprint from "Commerce & Industry", September, 1956

TABLE 6.

PERCENTAGE FREQUENCY OF FOOD ORGANISMS OF THE CAPE CORMORANT.*

Month.	Pilchard.	Maas-banker.	Anchovy.	Klipfish.	Hottentot.	Fish Remains.	Rock Lobster.	Shrimp.
1954—	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
March	13	—	—	38	—	25	13	13
April	50	—	—	—	—	50	—	—
May	67	—	—	—	—	—	—	—
June	—	—	—	—	—	—	—	—
July	—	—	—	83	—	—	—	—
August	—	—	100	—	—	—	—	—
September	43	14	43	14	—	7	—	—
October	78	22	—	—	—	6	—	17
November	—	44	—	11	11	89	—	11
December	—	—	—	—	—	—	—	—
1955—								
January	63	—	—	13	—	25	—	—
February	80	40	20	—	—	20	—	—

* Calculated from columns 5 and 13 of Table 4.

TABLE 7.

MEAN TOTAL ESTIMATED WEIGHT OF FOOD ORGANISM PER BIRD.*

Month.	Pilchard.	Maas-banker.	Anchovy.	Klipfish.	Hottentot.	Fish Remains.	Shrimp.
1954—	gm	gm	gm	gm	gm	gm	gm
March	15†	—	—	62†	—	21†	13†
April	46†	—	—	—	—	11†	—
May	140	—	—	—	—	—	—
June	—	—	—	—	—	—	—
July	—	—	—	—	—	16†	—
August	—	—	41	—	—	—	—
September	151	130	225	54†	—	15†	—
October	246	—	156	—	—	20†	6†
November	—	12†	—	10†	4†	18†	1†
December	—	—	—	—	—	—	—
1955—							
January	99	—	—	32†	—	21†	—
February	1,378	6†	91†	—	—	50	—

* Calculated from columns 5 and 11 of Table 4.

† Calculated from actual weights.

Table 8.

The Digestion of the Cape Cormorant.

Bird Number.	Food Organism.	Number Fed.	Mean total Length.	Total weight at Time of Feeding.	Total weight after Period of Digestion.	Difference.	Total volume at Time of Feeding.	Total volume after Period of Digestion.	Difference.	Time allowed for Digestion.		Weight of Bird.		Remarks.
			cm	gm	gm	gm	cc	cc	cc	hrs.	mins.	lb.	oz.	
1	Harder..	1	9·8	8·1	0·6	7·5 (93%)	8	0·5	7·5	—	30	2	—	Soft parts completely gone from stomach, few small bones and scales only at posterior end.
2	Harder..	6	9·6	42·1	23·0	19·1 (45%)	—	—	—	1	—	—	—	2 fish in posterior region of stomach mush; remaining 4 softened.
3	Harder..	12	7·2	42·1	4·8	37·3 (89%)	—	—	—	2	—	2	4	Complete evacuation of stomach except for remains of fins, scales, eyeballs and bones.
4	Harder..	30	7·5	150·5	—	—	—	—	—	—		2	11	Stomach contents regurgitated and bird would not retain fish.

Reprint from "Commerce & Industry", September, 1956

TABLE 9.

CORMORANT COUNTS IN ST. HELENA BAY.

Month.	Lowest Count.	Highest Count.	Mean.	Number of Counts made.	Mean Number of Flights.	Mean Number of Birds per Flight.	Remarks.
1953—							
November....	2,024	7,135	4,286	4	61	55	Weather mainly fine.
December....	nil	1,200	600	4	—	—	Weather fine; no birds seen on two occasions.
1954—							
January.....	nil	5,100	1,567	5	51	37	Weather fine; no birds seen on one occasion.
February.....	40	40	40	1	2	20	—
March.....	74	3,428	1,345	5	48	21	Weather fine.
April.....	110	361	212	8	58	5	Weather fine.
May.....	118	630	299	6	77	19	Weather mainly overcast.
June.....	13,570	23,035	17,798	3	92	207	Weather fine.
July.....	36	13,941	4,826	8	53	72	Overcast and fine weather.
August.....	39	3,635	1,297	6	41	37	Strong SE winds.
September....	142	6,850	2,749	5	43	113	Weather fine.
October.....	5,085	16,154	8,891	4	98	118	Weather fine.
November....	302	8,040	4,592	6	52	88	Overcast and fine weather.
December....	345	3,415	1,880	2	68	26	Weather overcast.
1955—							
January.....	180	1,992	1,092	4	49	18	Weather fine.
February.....	139	16,839	8,425	4	134	63	Fog.
March.....	212	20,500	6,616	7	87	52	Weather fine.
April.....	139	12,380	3,950	5	39	106	Weather fine.
May.....	72	4,712	1,621	3	37	40	Fog.
June.....	2,229	41,113	16,312	8	41	333	Weather fine and overcast.
July.....	6,980	21,011	15,310	6	31	559	Overcast.
August.....	4,240	9,352	5,332	4	30	194	Weather fine.
September....	1,936	17,835	7,710	6	42	483	Weather fine.
October.....	52	7,115	2,017	9	28	55	Weather fine.

Table 10.—The Food of the Cape Penguin.

Month.	Locality.	Surf. Temp.	Food Organism in Stomach.	Number of Birds in which Found.	Highest Number of organisms per Bird.	Total Number from all Birds.	Mean Total length of Food Organisms.	Total Weight of all Food Organisms.	Mean Weight per Organism.	Total Weight of all organisms at time of Eating.	Mean Weight per organism at time of Eating.	Number of Birds Shot.	Remarks.
1954.		°C					cm	gm	gm	gm	gm		
March.....	St. Helena Bay.	14·9	Pilchard.....	2	1	2	—	36·5	18·3	—	—	14	Very much digested.
			Anchovy.....	1	1	1	± 6·0	3·6	3·6	5·0*	5·0*		Very much digested juvenile.
			Fish remains.	4	—	—	—	92·7	—	—	—		Small fish—unrecognisable.
			Squid.....	1	1	1	—	16·0	16·0	—	—		*Loligo reynaudi.*
			Empty.....	6	—	—	—	—	—	—	—		
April.....	St. Helena Bay.	14·4	Pilchard.....	8	52	160	5·6	719·9	4·5	800·0*	5·0*	13	Juveniles in varying stages of digestion.
			Maasbanker..	1	2	2	—	38·1	19·0	—	—		Very much digested.
			Anchovy.....	12	±200	887	4·5	1,321·6	1·5	3,548·0*	4·0*		Very much digested.
May.....	St. Helena Bay.	15·5	Pilchard.....	4	2	8	25·5	757·4	94·7	1,128·0*	141·0*	5	Mainly well digested.
			Fish remains.	1	—	—	—	5·3	—	—	—		Unrecognisable.
June.....	St. Helena Bay.	13·6	Pilchard.....	2	20	35	10·0	345·0	9·8	350·0*	10·0*	8	Freshly eaten.
			Fish remains.	2	—	—	—	111·4	—	—	—		Unrecognisable.
			Empty.....	4	—	—	—	—	—	—	—		
July.....	St. Helena Bay.	12·3	Pilchard.....	1	1	1	24·5	102·3	102·3	133·0*	133·0*	10	Slightly digested.
			Fish remains.	1	—	—	—	24·3	—	—	—		Unrecognisable.
			Empty.....	5	—	—	—	—	—	—	—		
August.....	St. Helena Bay.	12·4	Pilchard.....	4	2	10	24·6	918·6	91·9	1,340·0*	134·0*	9	Much digested.
			Anchovy.....	3	30	59	12·5	455·8	7·7	767·0*	13·0*		Much digested.
			Fish remains.	1	—	—	—	56·1	—	—	—		Unrecognisable.
			Crab larvae..	1	27	27	—	5·5	0·2	—	—		*Megalopae.*
September....	St. Helena Bay.	12·0	Pilchard.....	2	1	2	24·5	148·5	74·3	266·0*	133·0*	3	Much digested.
			Anchovy.....	2	7	14	9·3	144·2	10·3	144·2	10·3		Freshly eaten.
			Fish remains.	1	—	—	—	16·7	—	—	—		Unrecognisable.
October.....	St. Helena Bay.	13·2	Pilchard.....	4	2	6	26·5	681·1	113·5	960·0*	160·0*	9	Much digested.
			Anchovy.....	8	26	± 80	±13·0	861·3	± 10·0	1,120·0*	14·0*		Much digested.
November....	St. Helena Bay.	13·3	Maasbanker..	2	1	2	—	46·5	23·3	—	—	11	Very much digested.
			Mackerel....	1	2	2	—	—	—	—	—		Details not given.
			Anchovy.....	4	± 12	± 25	±10·0	164·0	± 6·6	275·0*	11·0*		Mainly well digested.
			Fish remains.	3	—	—	—	166·6	—	—	—		Mainly small fish, probably Anchovies.
			Empty.....	1	—	—	—	—	—	—	—		
December.....	St. Helena Bay.	15·2	Anchovy.....	1	1	1	9·4	10·3	10·3	10·3	10·3	4	Freshly eaten.
			Empty.....	3	—	—	—	—	—	—	—		
1955.													
January.....	St. Helena Bay.	14·7	Pilchard.....	3	50	135	8·5	828·0	6·1	1,215·0*	9·0*	16	Much digested.
			Anchovy.....	1	1	1	12·5	13·0	13·0	13·0	13·0		Freshly eaten.
			Fish remains.	11	—	—	—	215·3	—	—	—		Unrecognisable.
			Squid.....	1	1	1	—	31·0	31·0	—	—		*Loligo reynaudi.*
			Empty.....	1	—	—	—	—	—	—	—		
February.....	St. Helena Bay.	15·3	Pilchard.....	7	6	40	10·5	289·0	7·2	400·0*	11·0*	10	Much digested.
			Maasbanker..	2	4	5	7·5	53·2	10·6	55·0*	11·0*		Freshly eaten.
			Anchovy.....	5	9	18	11·0	177·5	9·8	216·0*	12·0*		Much digested.
			Fish remains.	1	—	—	—	49·0	—	—	—		Unrecognisable.
			Squid.....	1	1	1	—	13·0	—	—	—		*Loligo reynaudi.*
											Total.	112	

* Calculated from available data.

Reprint from "Commerce & Industry", September, 1956

TABLE 11.

PERCENTAGE FREQUENCY OF FOOD ORGANISMS OF THE CAPE PENGUIN.*

Month.	Pilchard.	Maas-banker.	Anchovy.	Mackerel.	Fish Remains.	Squid.	Crab Larvae.	Empty.
1954—	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
March	14	—	7	—	29	7	—	43
April	62	8	92	—	—	—	—	—
May	80	—	—	—	20	—	—	—
June	25	—	—	—	25	—	—	50
July	10	—	—	—	—	—	—	50
August	45	—	33	—	11	—	11	—
September	67	—	67	—	33	—	—	—
October	45	—	89	—	—	—	—	—
November	18	—	36	9	27	—	—	9
December	—	—	25	—	—	—	—	75
1955—								
January	19	—	6	—	69	6	—	6
February	70	20	50	—	10	10	—	—

* Calculated from Columns 5 and 13 of Table 7.

TABLE 12.

MEAN TOTAL ESTIMATED WEIGHT OF FOOD ORGANISM PER BIRD.*

Month.	Pilchard.	Maas-banker.	Anchovy.	Fish Remains.	Squid.	Crab Larvae.
1954—	gm	gm	gm	gm	gm	gm
March	18†	—	5	23†	16†	—
April	100	38†	296	—	—	—
May	282	—	—	5†	—	—
June	175	—	—	57†	—	—
July	133	—	—	24†	—	—
August	335	—	256	56†	—	6†
September	133	—	72	17†	—	—
October	240	—	140	—	—	—
November	—	23†	69	56†	—	—
December	—	—	10	—	—	—
1955—						
January	405	—	13†	20†	31†	—
February	57	27	43	49†	13†	—

* Calculated from Columns 5 and 11 of Table 7.

† Calculated from actual weights.

Table 13.

The Digestion of the Cape Penguin.

Bird Number.	Food Organism.	Number Fed.	Mean Total Length.	Total weight at time of Feeding.	Total weight after period of Digestion.	Difference.	Time allowed for Digestion.		Weight of Bird.		Remarks.
			cm	gm	gm	gm	hrs.	mins.	lb.	oz	
1.....	Pilchard...	1⅓	26·4	192	146	46 (24%)	2	—	3	4	Stomach contents very soft, beginning to disintegrate and green at posterior end of stomach.
2.....	Pilchard...	1⅓	25·8	192	98	94 (49%)	3	—	8	2	Stomach half evacuated, only mush remaining.
3.....	Pilchard...	1⅓	26·2	192	49	143 (74%)	4	—	8	4	Only small quantity of mush remaining in stomach.

Table 14.

Wind Frequencies per Thousand for Cape Columbine.*

Month.	N	NE	E	SE	S	SW	W	NW	Calm.
January.....	39·6	36·3	4·0	111·5	669·6	60·6	25·9	36·3	16·2
February.....	45·2	37·3	13·3	94·0	660·4	52·3	23·9	47·0	26·6
March.....	69·4	75·8	21·8	142·7	508·2	48·3	44·3	54·0	35·5
April.....	116·3	70·2	37·6	157·2	362·1	76·9	42·6	90·3	46·8
May.....	177·7	123·7	42·0	136·5	236·6	74·3	54·1	118·0	37·1
June.....	165·1	134·2	46·6	158·3	194·2	69·2	56·6	137·5	38·3
July.....	163·2	117·0	58·9	149·4	173·1	54·1	67·0	176·9	40·4
August.....	119·6	83·1	38·3	151·0	232·6	84·0	73·5	177·8	50·1
September.....	83·3	59·2	31·7	155·8	367·5	87·5	60·8	110·9	43·3
October.....	92·0	45·2	27·4	133·9	421·0	68·4	71·9	109·6	30·6
November.....	51·8	25·1	9·2	98·7	566·9	105·3	60·2	66·1	16·7
December.....	46·0	20·2	8·1	71·7	649·9	91·1	42·8	62·1	8·1
Year.....	97·4	69·0	27·4	130·1	420·2	72·6	52·0	98·8	32·5
Beaufort Force 2.....	35·0	21·6	8·0	41·7	117·0	28·8	19·4	35·4	—
3.....	23·3	11·2	4·6	32·2	123·0	15·6	8·6	23·3	—
4.....	6·5	2·6	1·8	17·0	73·8	4·3	3·5	7·9	—
5, 6, 7.....	3·3	0·9	0·7	8·5	41·8	4·3	3·1	6·7	—
8+.....	0·1	—	—	0·1	0·4	—	0·1	0·3	—

* Data provided by the Weather Bureau, Pretoria, and based on hourly observations between 0830 and 1500 hours taken daily over a period of ten years, 1939–1948.

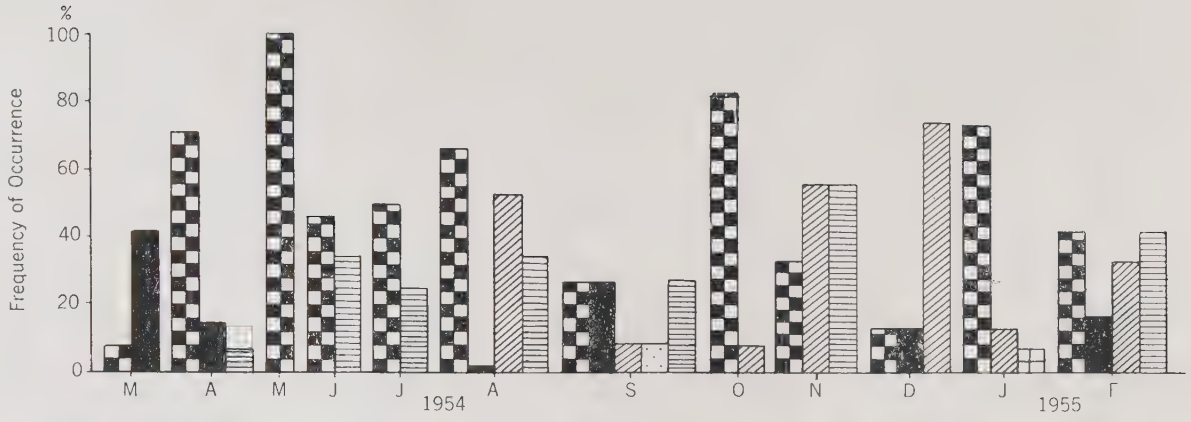


FIG. 1 By Frequency

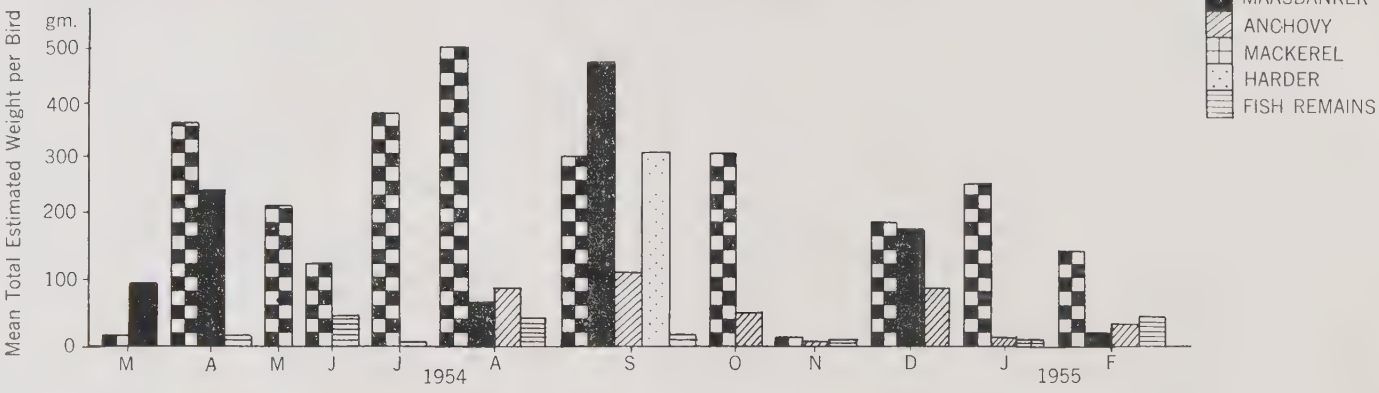


FIG. 2 By Weight

PLATE 1 THE FOOD OF THE CAPE GANNET

Trigsurvey, 1956.

Government Printer, 1956.

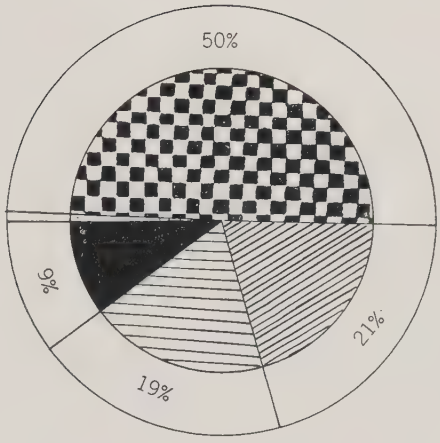
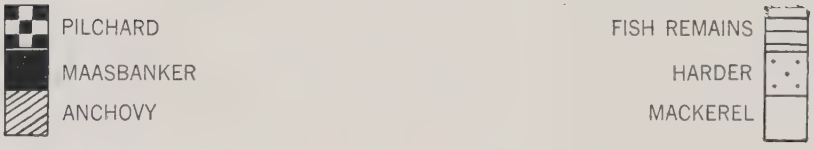


FIG. 1 By Frequency



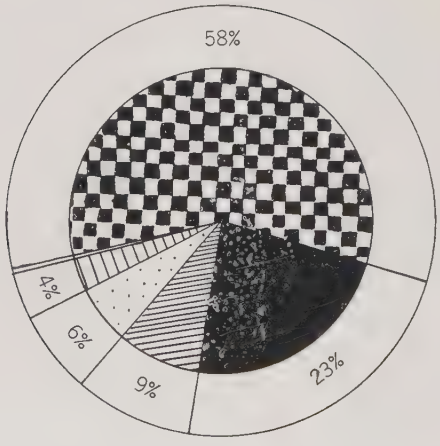


FIG. 2 By Weight

PLATE 2 FOOD DIAGRAM FOR THE CAPE GANNET

Government Printer, 1956.

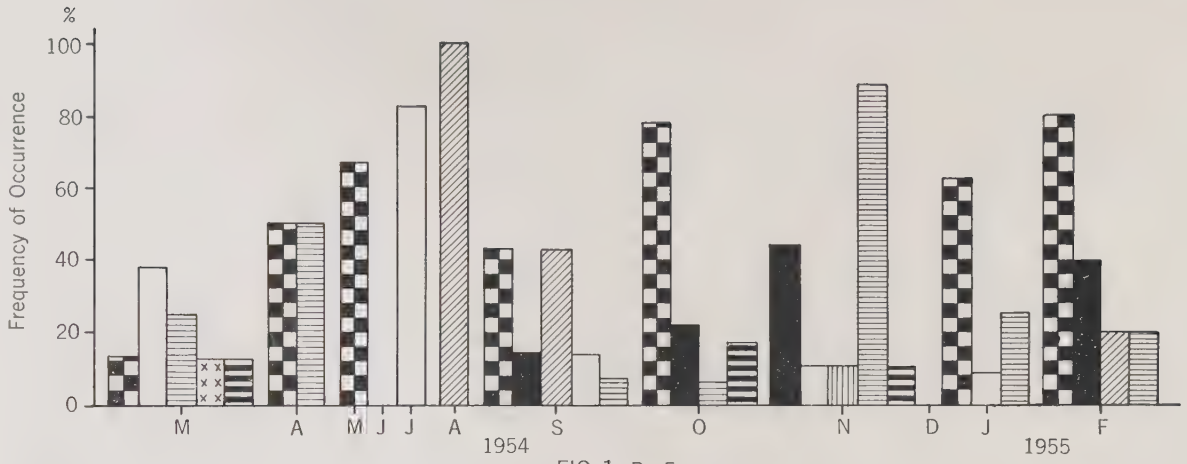


FIG. 1 By Frequency

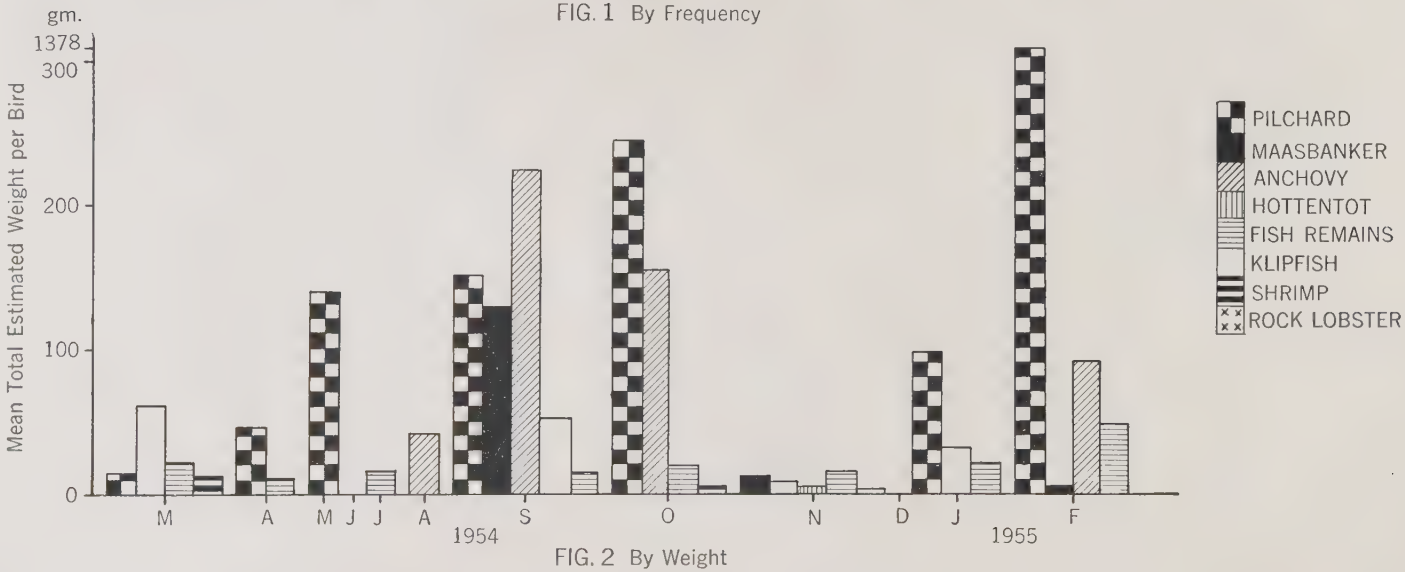


FIG. 2 By Weight

PLATE 3 THE FOOD OF THE CAPE CORMORANT

Trigsurvey, 1956

Government Printer, 1956.

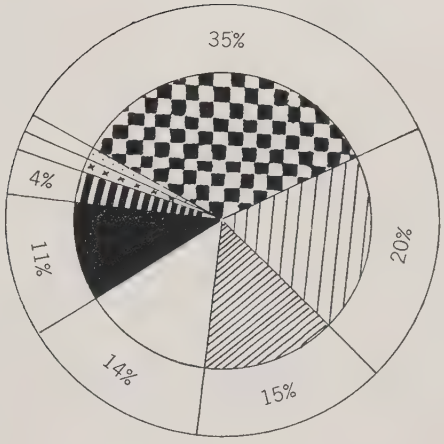
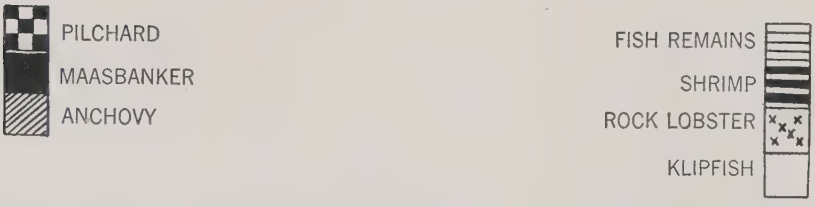


FIG. 1 By Frequency



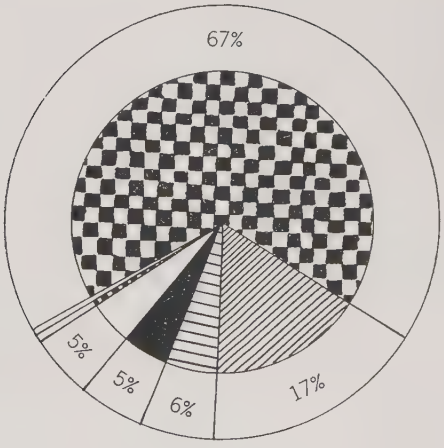


FIG. 2 By Weight

PLATE 4 FOOD DIAGRAM FOR THE CAPE CORMORANT

Government Printer, 1956.

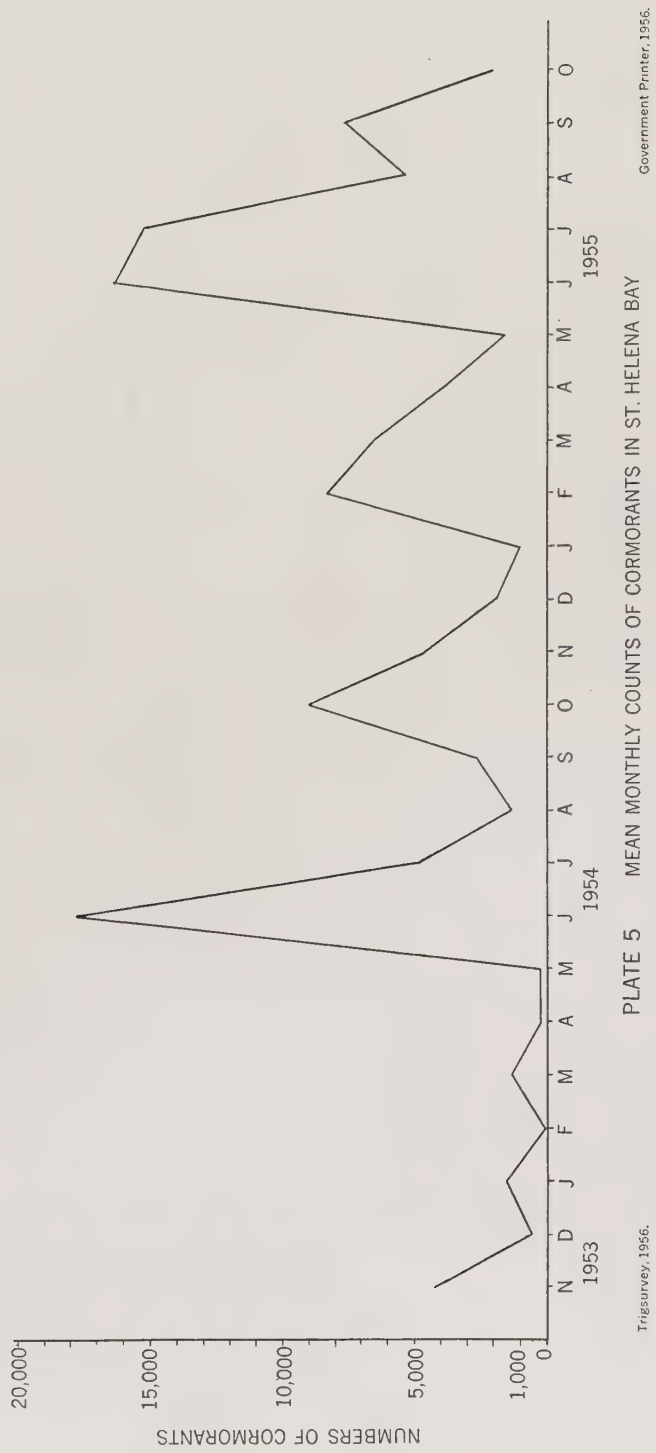


PLATE 5 MEAN MONTHLY COUNTS OF CORMORANTS IN ST. HELENA BAY

Trigsurvey, 1956. Government Printer, 1956.

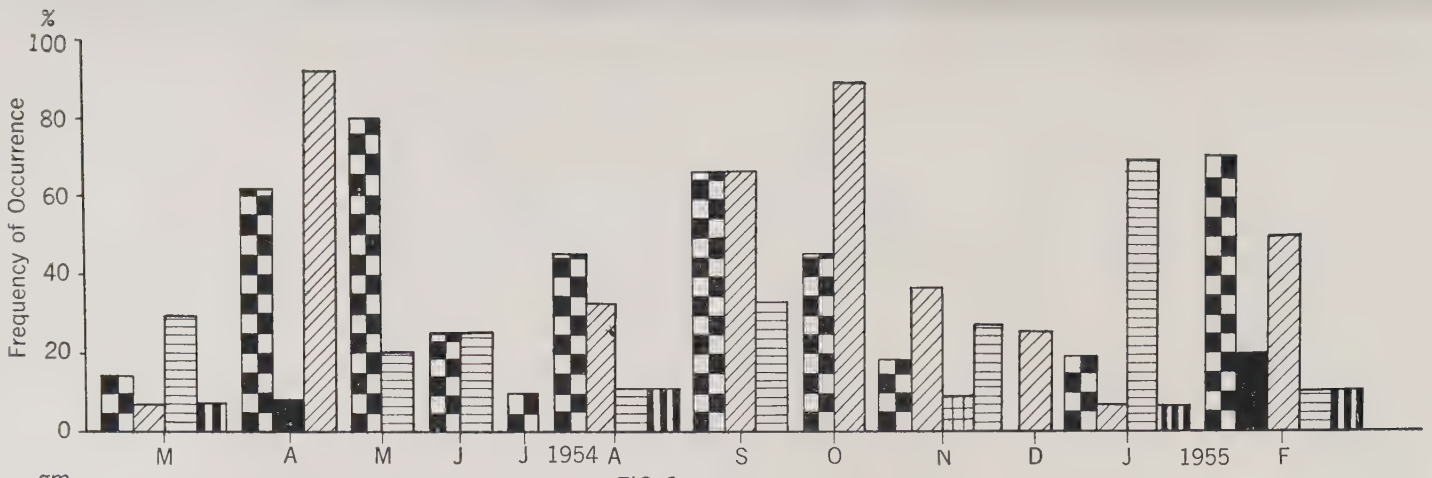


FIG. 1 By Frequency

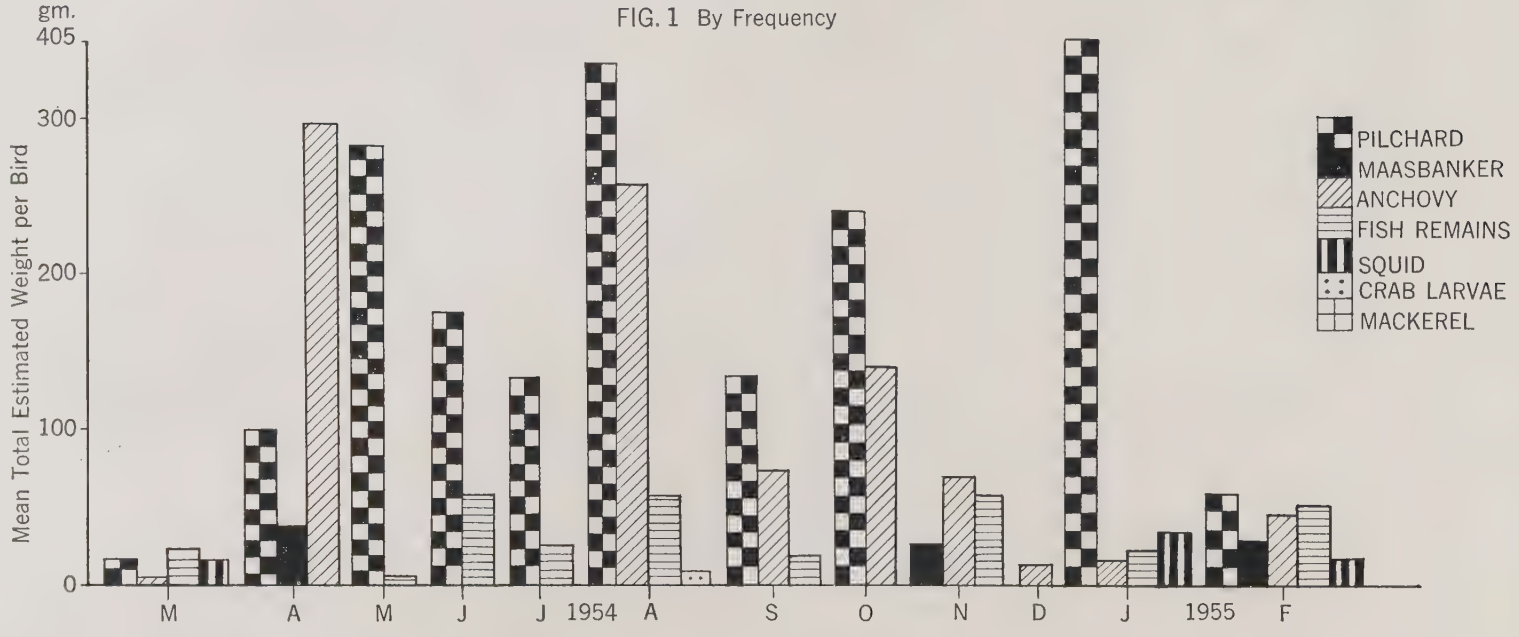


FIG. 2 By Weight

PLATE 6 THE FOOD OF THE CAPE PENGUIN

Trigsurvey, 1956.

Government Printer, 1956.

Reprint from "Commerce & Industry", September, 1956

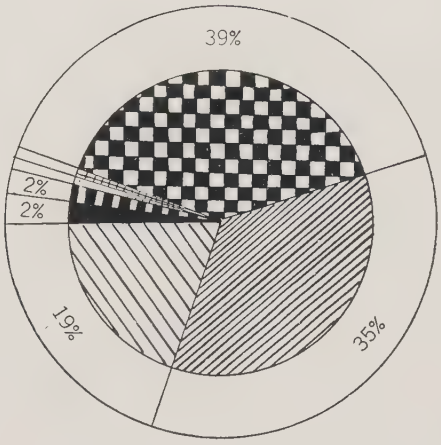


FIG. 1 By Frequency

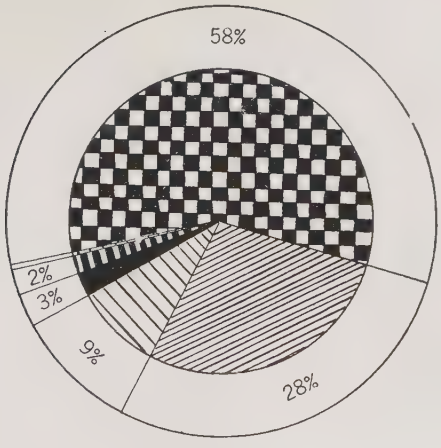
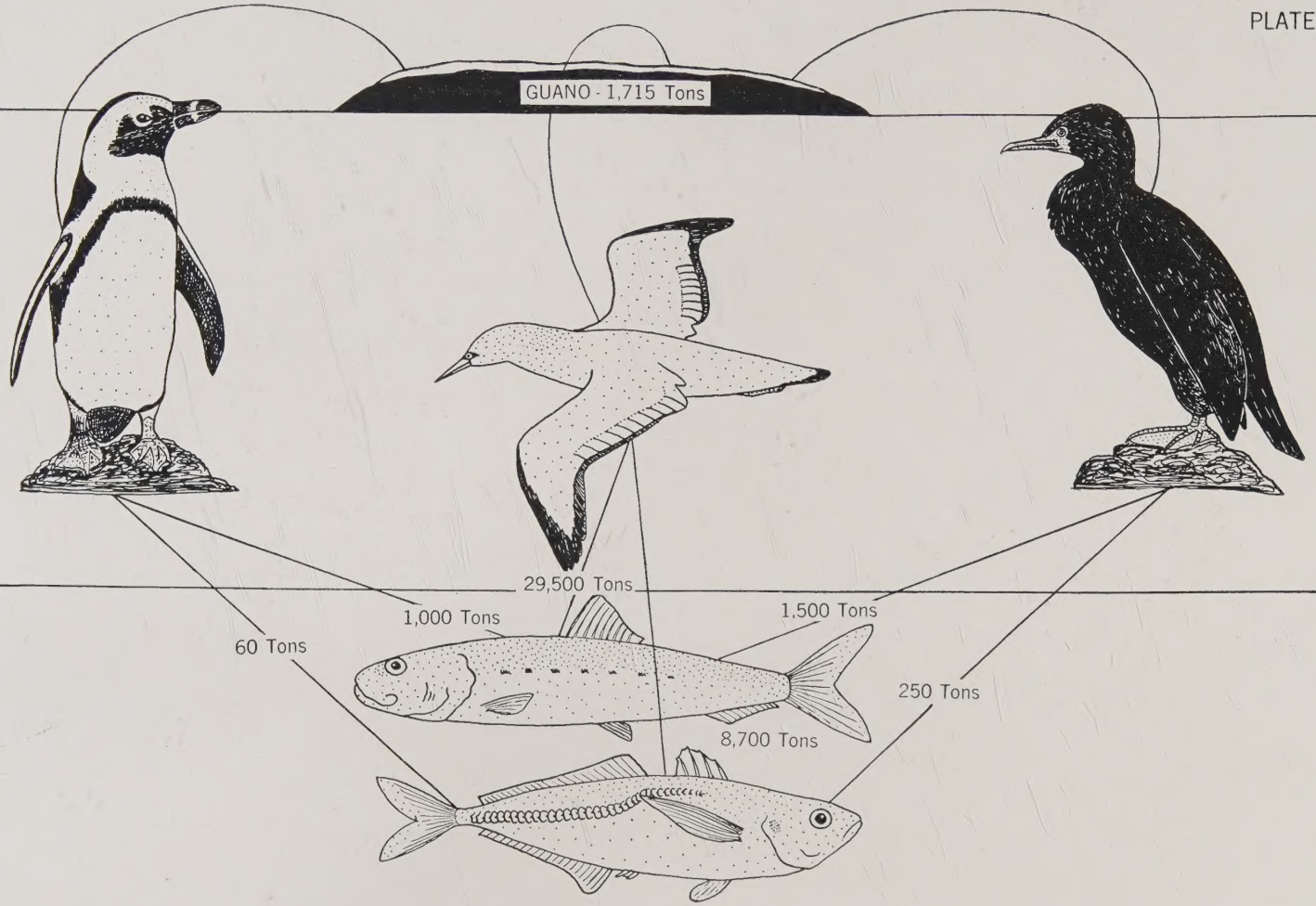


FIG. 2 By Weight

PLATE 7 FOOD DIAGRAM FOR THE CAPE PENGUIN

Government Printer, 1956.

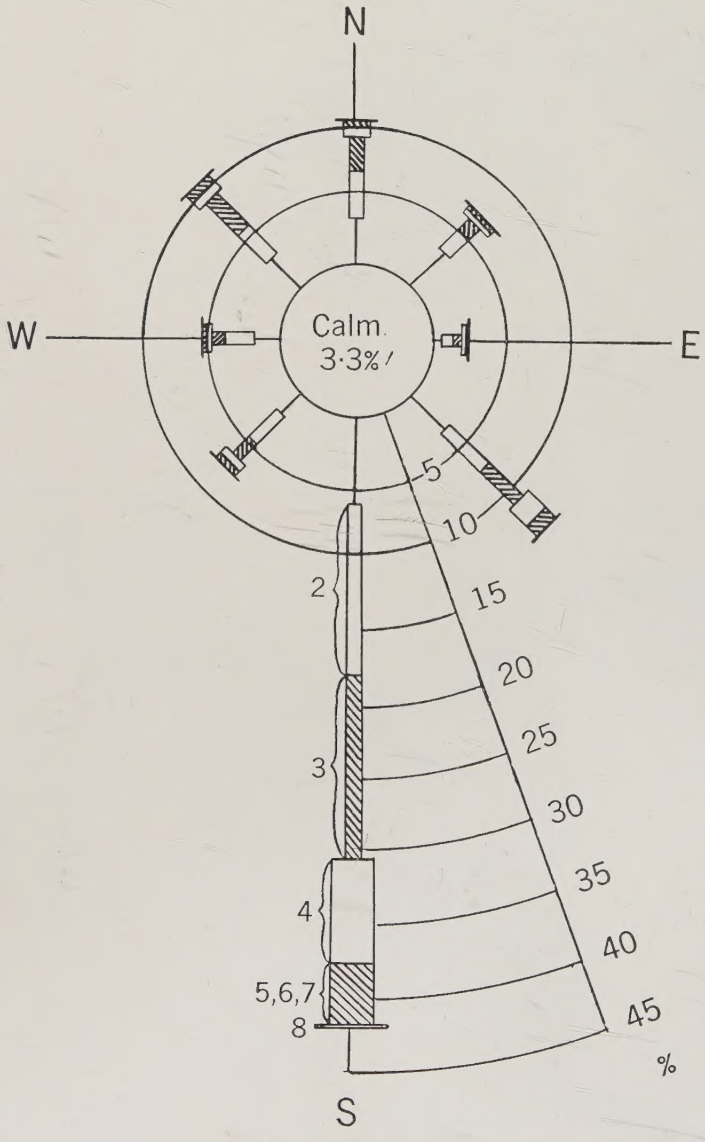


THE ST. HELENA - SALDANHA BAY AREA

Government Printer, 1956.

Reprint from "Commerce & Industry", September, 1956

PLATE 9



PERCENTAGE WIND FREQUENCIES FOR CAPE COLUMBINE.

(Numbers 2–8 apply to the Beaufort Scale)

From data provided by the Weather Bureau, Pretoria.

Government Printer, 1956.